



US008763877B2

(12) **United States Patent**
Schall et al.

(10) **Patent No.:** **US 8,763,877 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **SURGICAL INSTRUMENTS WITH
RECONFIGURABLE SHAFT SEGMENTS**

(75) Inventors: **Christopher J. Schall**, Cincinnati, OH
(US); **Jerome R. Morgan**, Cincinnati,
OH (US); **Frederick E. Shelton, IV**,
Hillsboro, OH (US)

(73) Assignee: **Ethicon Endo-Surgery, Inc.**, Cincinnati,
OH (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 446 days.

3,166,072 A	1/1965	Sullivan, Jr.
3,357,296 A	12/1967	Lefever
3,490,675 A	1/1970	Green et al.
3,551,987 A	1/1971	Wilkinson
3,643,851 A	2/1972	Green et al.
3,662,939 A	5/1972	Bryan
3,717,294 A	2/1973	Green
3,744,495 A	7/1973	Johnson
3,746,002 A	7/1973	Haller
3,819,100 A	6/1974	Noiles et al.
3,841,474 A	10/1974	Maier
3,885,491 A	5/1975	Curtis
RE28,932 E	8/1976	Noiles et al.

(Continued)

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **12/894,311**

CA	2458946 A1	3/2003
CA	2512960 A1	1/2006

(22) Filed: **Sep. 30, 2010**

(Continued)

(65) **Prior Publication Data**

US 2012/0080496 A1 Apr. 5, 2012

OTHER PUBLICATIONS

U.S. Appl. No. 12/775,809, filed May 7, 2010.

(51) **Int. Cl.**
A61B 17/068 (2006.01)

(Continued)

(52) **U.S. Cl.**
USPC **227/178.1**; 227/176.1; 227/179.1

Primary Examiner — Thanh Truong
Assistant Examiner — Nathaniel Chukwurah

(58) **Field of Classification Search**
USPC 227/176.1, 178.1, 179.1, 180.1, 181.1;
600/141

See application file for complete search history.

(57) **ABSTRACT**

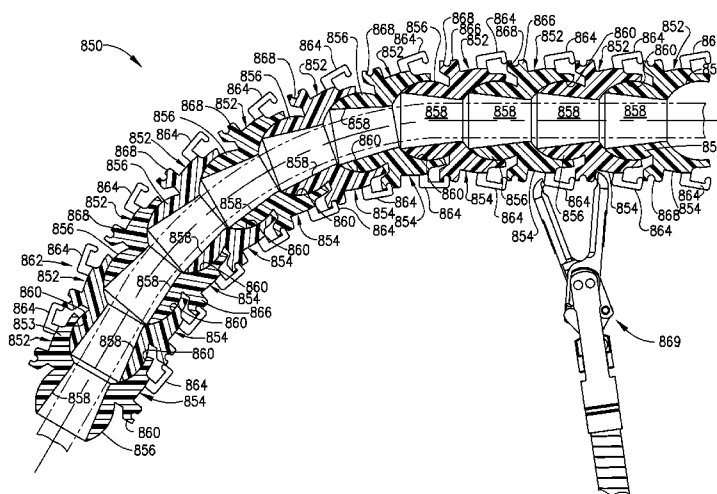
A surgical instrument having a handle assembly and an elongated shaft assembly protruding therefrom. Various embodiments of the elongated shaft assemblies include reconfigurable shaft segments that have portions that may be selectively arranged in coaxial alignment with each other and in other configurations wherein at least some portions thereof are not in coaxial alignment with each other. Various locking arrangements are disclosed for releasably locking the reconfigurable shaft segments in desired orientations. A movable closure tube is supported on the elongated shaft segment and is oriented to provide actuation motions to an end effector coupled to the distal end of the elongated shaft.

(56) **References Cited**

U.S. PATENT DOCUMENTS

662,587 A	11/1900	Blake
951,393 A	3/1910	Hahn
1,306,107 A	6/1919	Elliott
2,132,295 A	10/1938	Hawkins
2,161,632 A	6/1939	Nattenheimer
2,211,117 A	8/1940	Hess
2,674,149 A	4/1954	Benson
2,853,074 A	9/1958	Olson
3,032,769 A	5/1962	Palmer

14 Claims, 139 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

4,060,089 A	11/1977	Noiles	5,222,975 A	6/1993	Crainich
4,198,982 A	4/1980	Fortner et al.	5,234,447 A	8/1993	Kaster et al.
4,275,813 A	6/1981	Noiles	5,236,440 A	8/1993	Hlavacek
4,321,002 A	3/1982	Froehlich	5,258,009 A	11/1993	Conners
4,331,277 A	5/1982	Green	5,258,012 A	11/1993	Luscombe et al.
4,340,331 A	7/1982	Savino	5,263,973 A	11/1993	Cook
4,383,634 A	5/1983	Green	5,275,608 A	1/1994	Forman et al.
4,396,139 A	8/1983	Hall et al.	5,282,806 A	2/1994	Haber et al.
4,402,445 A	9/1983	Green	5,282,829 A	2/1994	Hermes
4,415,112 A	11/1983	Green	5,285,945 A	2/1994	Brinkerhoff et al.
4,429,695 A	2/1984	Green	5,304,204 A	4/1994	Bregen
4,434,796 A	3/1984	Karapetian et al.	5,333,772 A	8/1994	Rothfuss et al.
4,475,679 A	10/1984	Fleury, Jr.	5,336,232 A	8/1994	Green et al.
4,489,875 A	12/1984	Crawford et al.	5,342,395 A	8/1994	Jarrett et al.
4,500,024 A	2/1985	DiGiovanni et al.	5,342,396 A	8/1994	Cook
4,505,273 A	3/1985	Braun et al.	5,348,259 A	9/1994	Blanco et al.
4,505,414 A	3/1985	Filipi	5,350,400 A	9/1994	Esposito et al.
4,506,671 A	3/1985	Green	5,352,229 A	10/1994	Goble et al.
4,522,327 A	6/1985	Korthoff et al.	5,352,238 A	10/1994	Green et al.
4,530,453 A	7/1985	Green	5,358,510 A	10/1994	Luscombe et al.
4,531,522 A	7/1985	Bedi et al.	5,366,479 A	11/1994	McGarry et al.
4,532,927 A	8/1985	Mikszs, Jr.	5,397,324 A	3/1995	Carroll et al.
4,548,202 A	10/1985	Duncan	5,405,072 A	4/1995	Zlock et al.
4,566,620 A	1/1986	Green et al.	5,411,508 A	5/1995	Bessler et al.
4,573,468 A	3/1986	Conta et al.	5,413,272 A	5/1995	Green et al.
4,573,622 A	3/1986	Green et al.	5,415,334 A	5/1995	Williamson, IV et al.
4,580,712 A	4/1986	Green	5,417,361 A	5/1995	Williamson, IV
4,589,416 A	5/1986	Green	5,425,745 A	6/1995	Green et al.
4,605,004 A	8/1986	Di Giovanni et al.	5,439,479 A	8/1995	Schichman et al.
4,610,383 A	9/1986	Rothfuss et al.	5,441,191 A	8/1995	Linden
4,619,262 A	10/1986	Taylor	5,441,193 A	8/1995	Gravener
4,629,107 A	12/1986	Fedotov et al.	5,445,644 A	8/1995	Pietrafitta et al.
4,632,290 A	12/1986	Green et al.	5,452,837 A	9/1995	Williamson, IV et al.
4,655,222 A	4/1987	Florez et al.	5,468,253 A	11/1995	Bezwada et al.
4,664,305 A	5/1987	Blake, III et al.	5,474,566 A	12/1995	Alesi et al.
4,671,445 A	6/1987	Barker et al.	5,478,354 A	12/1995	Tovey et al.
4,715,520 A	12/1987	Roehr, Jr. et al.	5,480,089 A	1/1996	Blewett
4,728,020 A	3/1988	Green et al.	5,482,197 A	1/1996	Green et al.
4,752,024 A	6/1988	Green et al.	5,484,095 A	1/1996	Green et al.
4,754,909 A *	7/1988	Barker et al. 227/19	5,484,451 A	1/1996	Akopov et al.
4,767,044 A	8/1988	Green	5,485,947 A	1/1996	Olson et al.
4,773,420 A	9/1988	Green	5,485,952 A	1/1996	Fontayne
4,805,617 A	2/1989	Bedi et al.	5,487,499 A	1/1996	Sorrentino et al.
4,805,823 A	2/1989	Rothfuss	5,487,500 A	1/1996	Knodel et al.
4,809,695 A	3/1989	Gwathmey et al.	5,489,058 A	2/1996	Plyley et al.
4,817,847 A	4/1989	Redtenbacher et al.	5,497,933 A	3/1996	DeFonzo et al.
4,819,853 A	4/1989	Green	5,503,320 A	4/1996	Webster et al.
4,821,939 A	4/1989	Green	5,503,635 A	4/1996	Sauer et al.
4,834,720 A	5/1989	Blinkhorn	5,505,363 A	4/1996	Green et al.
4,844,068 A	7/1989	Arata et al.	5,507,426 A	4/1996	Young et al.
4,869,414 A	9/1989	Green et al.	5,509,596 A	4/1996	Green et al.
4,869,415 A	9/1989	Fox	5,520,700 A	5/1996	Beyar et al.
4,890,613 A	1/1990	Golden et al.	5,529,235 A	6/1996	Boiarski et al.
4,930,674 A	6/1990	Barak	5,533,661 A	7/1996	Main et al.
4,932,960 A	6/1990	Green et al.	5,535,934 A	7/1996	Boiarski et al.
4,941,623 A	7/1990	Pruitt	5,540,375 A	7/1996	Bolanos et al.
4,944,443 A	7/1990	Odds et al.	5,542,594 A	8/1996	McKean et al.
5,042,707 A	8/1991	Taheri	5,549,621 A	8/1996	Bessler et al.
5,065,929 A	11/1991	Schulze et al.	5,549,628 A	8/1996	Cooper et al.
5,071,430 A	12/1991	de Salis et al.	5,553,765 A	9/1996	Knodel et al.
5,074,454 A	12/1991	Peters	5,554,169 A	9/1996	Green et al.
5,116,349 A	5/1992	Aranyi	5,560,530 A	10/1996	Bolanos et al.
5,122,156 A	6/1992	Granger et al.	5,560,532 A	10/1996	DeFonzo et al.
5,129,570 A	7/1992	Schulze et al.	5,562,241 A	10/1996	Knodel et al.
5,137,198 A	8/1992	Nobis et al.	5,562,682 A	10/1996	Oberlin et al.
5,139,513 A	8/1992	Segato	5,564,615 A	10/1996	Bishop et al.
5,141,144 A	8/1992	Foslien et al.	5,571,116 A	11/1996	Bolanos et al.
5,156,315 A	10/1992	Green et al.	5,571,285 A	11/1996	Chow et al.
5,156,614 A	10/1992	Green et al.	5,575,799 A	11/1996	Bolanos et al.
5,158,567 A	10/1992	Green	5,575,803 A	11/1996	Cooper et al.
D330,699 S	11/1992	Gill	5,577,654 A	11/1996	Bishop
5,171,253 A	12/1992	Klieman	5,580,067 A	12/1996	Hamblin et al.
5,211,649 A	5/1993	Kohler et al.	5,582,611 A	12/1996	Tsuruta et al.
5,221,036 A	6/1993	Takase	5,586,711 A	12/1996	Plyley et al.
5,222,963 A	6/1993	Brinkerhoff et al.	5,588,579 A	12/1996	Schnut et al.
			5,588,580 A	12/1996	Paul et al.
			5,588,581 A	12/1996	Conlon et al.
			5,601,224 A	2/1997	Bishop et al.
			5,603,443 A	2/1997	Clark et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

5,605,273 A	2/1997	Hamblin et al.	5,829,662 A	11/1998	Allen et al.
5,607,094 A	3/1997	Clark et al.	5,833,695 A	11/1998	Yoon
5,607,095 A	3/1997	Smith et al.	5,836,503 A	11/1998	Ehrenfels et al.
5,609,285 A	3/1997	Grant et al.	5,839,639 A	11/1998	Sauer et al.
5,620,452 A	4/1997	Yoon	5,855,311 A	1/1999	Hamblin et al.
5,624,452 A	4/1997	Yates	5,855,583 A	1/1999	Wang et al.
5,628,446 A	5/1997	Geiste et al.	5,865,361 A	2/1999	Milliman et al.
5,630,539 A	5/1997	Plyley et al.	5,868,760 A	2/1999	McGuckin, Jr.
5,630,540 A	5/1997	Blewett	5,871,135 A	2/1999	Williamson, IV et al.
5,632,432 A	5/1997	Schulze et al.	5,897,562 A	4/1999	Bolanos et al.
5,632,433 A	5/1997	Grant et al.	5,901,895 A	5/1999	Heaton et al.
5,634,584 A	6/1997	Okorochoa et al.	5,902,312 A	5/1999	Frater et al.
5,636,780 A	6/1997	Green et al.	5,908,427 A	6/1999	McKean et al.
5,639,008 A	6/1997	Gallagher et al.	5,911,353 A	6/1999	Bolanos et al.
5,649,937 A	7/1997	Bito et al.	5,915,616 A	6/1999	Viola et al.
5,651,491 A	7/1997	Heaton et al.	5,919,198 A	7/1999	Graves, Jr. et al.
5,653,373 A	8/1997	Green et al.	5,937,951 A	8/1999	Izuchukwu et al.
5,653,374 A	8/1997	Young et al.	5,941,442 A	8/1999	Geiste et al.
5,653,721 A	8/1997	Knodel et al.	5,954,259 A	9/1999	Viola et al.
5,655,698 A	8/1997	Yoon	5,964,774 A	10/1999	McKean et al.
5,657,921 A	8/1997	Young et al.	6,010,054 A	1/2000	Johnson et al.
5,662,258 A	9/1997	Knodel et al.	6,024,748 A	2/2000	Manzo et al.
5,662,260 A	9/1997	Yoon	6,032,849 A	3/2000	Mastri et al.
5,667,517 A	9/1997	Hooven	6,033,427 A	3/2000	Lee
5,667,527 A	9/1997	Cook	6,042,601 A	3/2000	Smith
5,669,544 A	9/1997	Schulze et al.	6,045,560 A	4/2000	McKean et al.
5,669,918 A	9/1997	Balazs et al.	6,053,390 A	4/2000	Green et al.
5,673,840 A	10/1997	Schulze et al.	6,053,922 A *	4/2000	Krause et al. 606/80
5,673,841 A	10/1997	Schulze et al.	6,063,097 A	5/2000	Oi et al.
5,680,981 A	10/1997	Mililli et al.	6,083,234 A	7/2000	Nicholas et al.
5,680,982 A	10/1997	Schulze et al.	6,083,242 A	7/2000	Cook
5,685,474 A	11/1997	Seeber	6,086,600 A	7/2000	Kortenbach
5,690,269 A	11/1997	Bolanos et al.	6,099,551 A	8/2000	Gabbay
5,692,668 A	12/1997	Schulze et al.	6,102,271 A	8/2000	Longo et al.
5,695,504 A	12/1997	Gifford, III et al.	6,117,148 A	9/2000	Ravo et al.
5,695,524 A	12/1997	Kelley et al.	6,119,913 A	9/2000	Adams et al.
5,697,543 A	12/1997	Burdorff	6,126,058 A	10/2000	Adams et al.
5,697,943 A	12/1997	Sauer et al.	6,156,056 A	12/2000	Kearns et al.
5,702,408 A	12/1997	Wales et al.	6,171,330 B1	1/2001	Benchetrit
5,702,409 A	12/1997	Rayburn et al.	6,193,129 B1	2/2001	Bittner et al.
5,704,534 A	1/1998	Huitema et al.	6,197,042 B1	3/2001	Ginn et al.
5,711,472 A	1/1998	Bryan	6,202,914 B1	3/2001	Geiste et al.
5,713,505 A	2/1998	Huitema	6,241,139 B1	6/2001	Milliman et al.
5,715,987 A	2/1998	Kelley et al.	6,250,532 B1	6/2001	Green et al.
5,716,366 A	2/1998	Yates	6,258,107 B1	7/2001	Balázs et al.
5,718,360 A	2/1998	Green et al.	6,264,086 B1	7/2001	McGuckin, Jr.
5,725,536 A	3/1998	Oberlin et al.	6,264,087 B1	7/2001	Whitman
5,725,554 A	3/1998	Simon et al.	6,273,897 B1	8/2001	Dalessandro et al.
5,730,758 A	3/1998	Allgeyer	6,302,311 B1	10/2001	Adams et al.
5,732,871 A *	3/1998	Clark et al. 227/175.1	6,315,184 B1	11/2001	Whitman
5,732,872 A	3/1998	Bolduc et al.	6,325,810 B1	12/2001	Hamilton et al.
5,733,308 A	3/1998	Daugherty et al.	6,330,965 B1	12/2001	Milliman et al.
5,738,474 A	4/1998	Blewett	6,338,737 B1	1/2002	Toledano
5,743,456 A	4/1998	Jones et al.	6,387,113 B1	5/2002	Hawkins et al.
5,752,644 A	5/1998	Bolanos et al.	6,387,114 B2	5/2002	Adams
5,752,965 A	5/1998	Francis et al.	6,391,038 B2	5/2002	Vargas et al.
5,758,814 A	6/1998	Gallagher et al.	6,398,797 B2	6/2002	Bombard et al.
5,762,256 A	6/1998	Mastri et al.	6,402,766 B2	6/2002	Bowman et al.
5,766,188 A	6/1998	Igaki	6,419,695 B1	7/2002	Gabbay
5,769,892 A	6/1998	Kingwell	RE37,814 E	8/2002	Allgeyer
5,772,379 A	6/1998	Evensen	6,436,107 B1	8/2002	Wang et al.
5,779,130 A	7/1998	Alesi et al.	6,436,110 B2	8/2002	Bowman et al.
5,779,131 A	7/1998	Knodel et al.	6,440,146 B2	8/2002	Nicholas et al.
5,779,132 A	7/1998	Knodel et al.	6,443,973 B1	9/2002	Whitman
5,782,397 A	7/1998	Koukline	6,450,391 B1	9/2002	Kayan et al.
5,785,232 A	7/1998	Vidal et al.	6,488,196 B1	12/2002	Fenton, Jr.
5,797,536 A	8/1998	Smith et al.	6,488,197 B1	12/2002	Whitman
5,797,537 A	8/1998	Oberlin et al.	6,491,201 B1	12/2002	Whitman
5,797,538 A	8/1998	Heaton et al.	6,494,896 B1	12/2002	D'Alessio et al.
5,799,857 A	9/1998	Robertson et al.	6,500,194 B2	12/2002	Benderev et al.
5,806,676 A	9/1998	Wasgien	6,503,257 B2	1/2003	Grant et al.
5,810,855 A	9/1998	Rayburn et al.	6,503,259 B2	1/2003	Huxel et al.
5,814,057 A	9/1998	Oi et al.	6,505,768 B2	1/2003	Whitman
5,820,009 A	10/1998	Melling et al.	6,517,565 B1	2/2003	Whitman et al.
5,826,776 A	10/1998	Schulze et al.	6,517,566 B1	2/2003	Hovland et al.
			6,551,333 B2	4/2003	Kuhns et al.
			6,578,751 B2	6/2003	Hartwick
			6,588,643 B2	7/2003	Bolduc et al.
			6,592,597 B2	7/2003	Grant et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

6,601,749 B2	8/2003	Sullivan et al.	7,090,637 B2	8/2006	Danitz et al.
6,616,686 B2	9/2003	Coleman et al.	7,090,684 B2	8/2006	McGuckin, Jr. et al.
6,619,529 B2	9/2003	Green et al.	7,094,247 B2	8/2006	Monassevitch et al.
6,629,630 B2	10/2003	Adams	7,104,741 B2	9/2006	Krohn
6,629,988 B2	10/2003	Weadock	7,108,701 B2	9/2006	Evens et al.
6,638,285 B2	10/2003	Gabbay	7,108,709 B2	9/2006	Cummins
6,638,297 B1	10/2003	Huitema	7,111,769 B2	9/2006	Wales et al.
6,644,532 B2	11/2003	Green et al.	7,112,214 B2	9/2006	Peterson et al.
6,656,193 B2	12/2003	Grant et al.	7,114,642 B2	10/2006	Whitman
6,671,185 B2	12/2003	Duval	7,118,582 B1	10/2006	Wang et al.
6,681,978 B2	1/2004	Geiste et al.	7,121,446 B2	10/2006	Arad et al.
6,681,979 B2	1/2004	Whitman	7,128,253 B2	10/2006	Mastri et al.
6,685,727 B2	2/2004	Fisher et al.	7,128,254 B2	10/2006	Shelton, IV et al.
6,692,507 B2	2/2004	Pugsley et al.	7,128,748 B2	10/2006	Mooradian et al.
6,695,199 B2	2/2004	Whitman	7,140,527 B2	11/2006	Ehrenfels et al.
6,698,643 B2	3/2004	Whitman	7,143,926 B2	12/2006	Shelton, IV et al.
6,716,232 B1	4/2004	Vidal et al.	7,147,138 B2	12/2006	Shelton, IV
6,716,233 B1	4/2004	Whitman	7,147,139 B2	12/2006	Schwemberger et al.
6,722,552 B2	4/2004	Fenton, Jr.	7,156,863 B2	1/2007	Sonnenschein et al.
6,726,697 B2	4/2004	Nicholas et al.	7,159,750 B2	1/2007	Racenet et al.
6,736,854 B2	5/2004	Vadurro et al.	7,168,604 B2	1/2007	Milliman et al.
6,747,121 B2	6/2004	Gogolewski	7,179,267 B2	2/2007	Nolan et al.
6,755,338 B2	6/2004	Hahnen et al.	7,182,239 B1	2/2007	Myers
6,767,356 B2	7/2004	Kanner et al.	7,188,758 B2	3/2007	Viola et al.
6,769,590 B2	8/2004	Vresh et al.	7,207,471 B2	4/2007	Heinrich et al.
6,769,594 B2	8/2004	Orban, III	7,207,472 B2	4/2007	Wukusick et al.
6,773,438 B1	8/2004	Knodel et al.	7,207,556 B2	4/2007	Saitoh et al.
6,786,382 B1	9/2004	Hoffman	7,210,609 B2	5/2007	Leiboff et
6,805,273 B2	10/2004	Bilotti et al.	7,213,736 B2	5/2007	Wales et al.
6,817,508 B1	11/2004	Racenet et al.	7,220,272 B2	5/2007	Weadock
6,817,509 B2	11/2004	Geiste et al.	7,225,964 B2	6/2007	Mastri et al.
6,821,284 B2	11/2004	Sturtz et al.	7,234,624 B2	6/2007	Gresham et al.
6,830,174 B2	12/2004	Hillstead et al.	7,237,708 B1	7/2007	Guy et al.
6,837,846 B2 *	1/2005	Jaffe et al. 600/114	7,238,195 B2	7/2007	Viola
6,843,403 B2	1/2005	Whitman	7,246,734 B2	7/2007	Shelton, IV
RE38,708 E	3/2005	Bolanos et al.	7,258,262 B2	8/2007	Mastri et al.
6,863,694 B1	3/2005	Boyce et al.	7,267,679 B2	9/2007	McGuckin, Jr. et al.
6,866,178 B2	3/2005	Adams et al.	7,278,562 B2	10/2007	Mastri et al.
6,872,214 B2	3/2005	Sonnenschein et al.	7,278,563 B1	10/2007	Green
6,874,669 B2	4/2005	Adams et al.	7,296,724 B2	11/2007	Green et al.
6,877,647 B2	4/2005	Green et al.	7,303,106 B2	12/2007	Milliman et al.
6,905,057 B2	6/2005	Swayze et al.	7,303,107 B2	12/2007	Milliman et al.
6,913,608 B2	7/2005	Liddicoat et al.	7,303,108 B2	12/2007	Shelton, IV
6,939,358 B2	9/2005	Palacios et al.	7,308,998 B2	12/2007	Mastri et al.
6,945,444 B2	9/2005	Gresham et al.	7,328,828 B2	2/2008	Ortiz et al.
6,953,138 B1	10/2005	Dworak et al.	7,328,829 B2	2/2008	Arad et al.
6,953,139 B2	10/2005	Milliman et al.	7,334,717 B2	2/2008	Rethy et al.
6,959,851 B2	11/2005	Heinrich	7,334,718 B2	2/2008	McAlister et al.
6,959,852 B2	11/2005	Shelton, IV et al.	7,341,591 B2	3/2008	Grinberg
6,960,220 B2	11/2005	Marino et al.	7,354,447 B2	4/2008	Shelton, IV et al.
6,964,363 B2	11/2005	Wales et al.	7,357,287 B2	4/2008	Shelton, IV et al.
6,978,921 B2	12/2005	Shelton, IV et al.	7,364,060 B2	4/2008	Milliman
6,978,922 B2	12/2005	Bilotti et al.	7,364,061 B2	4/2008	Swayze et al.
6,981,628 B2	1/2006	Wales	7,377,928 B2	5/2008	Zubik et al.
6,981,978 B2	1/2006	Gannoe	7,380,695 B2	6/2008	Doll et al.
6,986,451 B1	1/2006	Mastri et al.	7,380,696 B2	6/2008	Shelton, IV et al.
6,988,649 B2	1/2006	Shelton, IV et al.	7,398,907 B2	7/2008	Racenet et al.
6,988,650 B2	1/2006	Schwemberger et al.	7,398,908 B2	7/2008	Holsten et al.
6,997,931 B2	2/2006	Sauer et al.	7,401,721 B2	7/2008	Holsten et al.
7,000,818 B2	2/2006	Shelton, IV et al.	7,404,508 B2	7/2008	Smith et al.
7,000,819 B2	2/2006	Swayze et al.	7,404,509 B2	7/2008	Ortiz et al.
7,008,435 B2	3/2006	Cummins	7,407,075 B2	8/2008	Holsten et al.
7,032,798 B2	4/2006	Whitman et al.	7,407,078 B2	8/2008	Shelton, IV et al.
7,032,799 B2	4/2006	Viola et al.	7,410,086 B2	8/2008	Ortiz et al.
7,041,868 B2	5/2006	Greene et al.	7,416,101 B2	8/2008	Shelton, IV et al.
7,044,352 B2	5/2006	Shelton, IV et al.	7,419,080 B2	9/2008	Smith et al.
7,044,353 B2	5/2006	Mastri et al.	7,422,136 B1	9/2008	Marczyk
7,055,731 B2	6/2006	Shelton, IV et al.	7,422,139 B2	9/2008	Shelton, IV et al.
7,056,330 B2	6/2006	Gayton	7,424,965 B2	9/2008	Racenet et al.
7,063,712 B2	6/2006	Vargas et al.	7,431,188 B1	10/2008	Marczyk
7,066,944 B2	6/2006	Laufer et al.	7,431,189 B2	10/2008	Shelton, IV et al.
7,070,083 B2	7/2006	Jankowski	7,431,730 B2	10/2008	Viola
7,077,856 B2	7/2006	Whitman	7,434,717 B2	10/2008	Shelton, IV et al.
7,080,769 B2	7/2006	Vresh et al.	7,438,209 B1	10/2008	Hess et al.
7,083,075 B2	8/2006	Swayze et al.	7,441,684 B2	10/2008	Shelton, IV et al.
			7,441,685 B1	10/2008	Boudreaux
			7,442,201 B2	10/2008	Pugsley et al.
			7,448,525 B2	11/2008	Shelton, IV et al.
			7,455,208 B2	11/2008	Wales et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

7,455,676 B2	11/2008	Holsten et al.	7,776,060 B2	8/2010	Mooradian et al.
7,455,682 B2	11/2008	Viola	7,780,054 B2	8/2010	Wales
7,464,846 B2	12/2008	Shelton, IV et al.	7,780,663 B2	8/2010	Yates et al.
7,464,847 B2	12/2008	Viola et al.	7,780,685 B2	8/2010	Hunt et al.
7,464,849 B2	12/2008	Shelton, IV et al.	7,784,662 B2	8/2010	Wales et al.
7,467,740 B2	12/2008	Shelton, IV et al.	7,793,812 B2	9/2010	Moore et al.
7,472,815 B2	1/2009	Shelton, IV et al.	7,794,475 B2	9/2010	Hess et al.
7,481,347 B2	1/2009	Roy	7,798,386 B2	9/2010	Schall et al.
7,481,349 B2	1/2009	Holsten et al.	7,799,039 B2	9/2010	Shelton, IV et al.
7,490,749 B2	2/2009	Schall et al.	7,810,692 B2	10/2010	Hall et al.
7,494,039 B2	2/2009	Racenet et al.	7,810,693 B2	10/2010	Broehl et al.
7,500,979 B2	3/2009	Hueil et al.	7,815,092 B2	10/2010	Whitman et al.
7,506,790 B2	3/2009	Shelton, IV	7,819,296 B2	10/2010	Hueil et al.
7,506,791 B2	3/2009	Omaits et al.	7,819,297 B2	10/2010	Doll et al.
7,510,107 B2	3/2009	Timm et al.	7,819,298 B2	10/2010	Hall et al.
7,546,940 B2	6/2009	Milliman et al.	7,819,299 B2	10/2010	Shelton, IV et al.
7,547,312 B2	6/2009	Bauman et al.	7,823,592 B2	11/2010	Bettuchi et al.
7,549,563 B2	6/2009	Mather et al.	7,828,189 B2	11/2010	Holsten et al.
7,549,564 B2	6/2009	Boudreaux	7,832,408 B2	11/2010	Shelton, IV et al.
7,556,185 B2	7/2009	Viola	7,832,611 B2	11/2010	Boyden et al.
7,556,186 B2	7/2009	Milliman	7,832,612 B2	11/2010	Baxter, III et al.
7,559,450 B2	7/2009	Wales et al.	7,837,080 B2	11/2010	Schwemmerger
7,559,452 B2	7/2009	Wales et al.	7,837,081 B2	11/2010	Holsten et al.
7,568,603 B2	8/2009	Shelton, IV et al.	7,845,533 B2	12/2010	Marczyk et al.
7,568,604 B2	8/2009	Ehrenfels et al.	7,845,537 B2	12/2010	Shelton, IV et al.
7,575,144 B2	8/2009	Ortiz et al.	7,857,185 B2	12/2010	Swayze et al.
7,588,175 B2	9/2009	Timm et al.	7,857,186 B2	12/2010	Baxter, III et al.
7,588,176 B2	9/2009	Timm et al.	7,861,906 B2	1/2011	Doll et al.
7,597,229 B2	10/2009	Boudreaux et al.	7,866,527 B2	1/2011	Hall et al.
7,604,150 B2	10/2009	Boudreaux	7,871,418 B2	1/2011	Thompson et al.
7,604,151 B2	10/2009	Hess et al.	7,900,805 B2	3/2011	Shelton, IV et al.
7,607,557 B2	10/2009	Shelton, IV et al.	7,905,380 B2	3/2011	Shelton, IV et al.
7,611,038 B2	11/2009	Racenet et al.	7,905,381 B2	3/2011	Baxter, III et al.
7,624,902 B2	12/2009	Marczyk et al.	7,909,221 B2	3/2011	Viola et al.
7,631,793 B2	12/2009	Rethy et al.	7,913,891 B2	3/2011	Doll et al.
7,635,074 B2	12/2009	Olson et al.	7,914,543 B2	3/2011	Roth et al.
7,637,409 B2	12/2009	Marczyk	7,918,376 B1	4/2011	Knodel et al.
7,641,095 B2	1/2010	Viola	7,918,377 B2	4/2011	Measamer et al.
7,644,848 B2	1/2010	Swayze et al.	7,922,061 B2	4/2011	Shelton, IV et al.
7,651,498 B2	1/2010	Shifrin et al.	7,922,063 B2	4/2011	Zemlok et al.
7,658,311 B2	2/2010	Boudreaux	7,934,630 B2	5/2011	Shelton, IV et al.
7,658,312 B2	2/2010	Vidal et al.	7,938,307 B2	5/2011	Bettuchi
7,665,646 B2	2/2010	Prommersberger	7,942,890 B2	5/2011	D'Agostino et al.
7,665,647 B2	2/2010	Shelton, IV et al.	7,950,560 B2	5/2011	Zemlok et al.
7,669,746 B2	3/2010	Shelton, IV	7,954,682 B2	6/2011	Giordano et al.
7,669,747 B2	3/2010	Weisenburgh, II et al.	7,954,684 B2	6/2011	Boudreaux
7,670,334 B2	3/2010	Hueil et al.	7,954,686 B2	6/2011	Baxter, III et al.
7,673,780 B2	3/2010	Shelton, IV et al.	7,959,051 B2	6/2011	Smith et al.
7,673,781 B2	3/2010	Swayze et al.	7,966,799 B2	6/2011	Morgan et al.
7,673,782 B2	3/2010	Hess et al.	7,967,180 B2	6/2011	Scirica
7,673,783 B2	3/2010	Morgan et al.	7,980,443 B2	7/2011	Scheib et al.
7,682,307 B2	3/2010	Danitz et al.	7,997,469 B2	8/2011	Olson et al.
7,699,204 B2	4/2010	Viola	8,002,795 B2	8/2011	Beetel
7,699,859 B2	4/2010	Bombard et al.	8,006,889 B2	8/2011	Adams et al.
7,708,180 B2	5/2010	Murray et al.	8,011,551 B2	9/2011	Marczyk et al.
7,717,312 B2	5/2010	Beetel	8,011,555 B2	9/2011	Tarinelli et al.
7,718,556 B2	5/2010	Matsuda et al.	8,016,177 B2	9/2011	Bettuchi et al.
7,721,930 B2	5/2010	McKenna et al.	8,025,199 B2	9/2011	Whitman et al.
7,721,931 B2	5/2010	Shelton, IV et al.	8,028,883 B2	10/2011	Stopek
7,721,934 B2	5/2010	Shelton, IV et al.	8,034,077 B2	10/2011	Smith et al.
7,721,936 B2	5/2010	Shelton, IV et al.	8,038,045 B2	10/2011	Bettuchi et al.
7,726,537 B2	6/2010	Olson et al.	8,038,046 B2	10/2011	Smith et al.
7,726,538 B2	6/2010	Holsten et al.	8,062,330 B2	11/2011	Prommersberger et al.
7,731,072 B2	6/2010	Timm et al.	D650,074 S	12/2011	Hunt et al.
7,735,703 B2	6/2010	Morgan et al.	8,083,119 B2	12/2011	Prommersberger
7,738,971 B2	6/2010	Swayze et al.	8,091,756 B2	1/2012	Viola
7,740,159 B2	6/2010	Shelton, IV et al.	8,097,017 B2	1/2012	Viola
7,743,960 B2	6/2010	Whitman et al.	8,100,310 B2	1/2012	Zemlok
7,744,627 B2	6/2010	Orban, III et al.	8,123,103 B2	2/2012	Milliman
7,748,587 B2	7/2010	Haramiishi et al.	8,123,767 B2	2/2012	Bauman et al.
7,753,245 B2	7/2010	Boudreaux et al.	8,128,645 B2	3/2012	Sonnenschein et al.
7,753,904 B2	7/2010	Shelton, IV et al.	8,152,041 B2	4/2012	Kostrzewski
7,766,209 B2	8/2010	Baxter, III et al.	8,157,152 B2	4/2012	Holsten et al.
7,766,210 B2	8/2010	Shelton, IV et al.	8,162,138 B2	4/2012	Bettenhausen et al.
7,770,775 B2	8/2010	Shelton, IV et al.	8,167,895 B2	5/2012	D'Agostino et al.
			8,192,460 B2	6/2012	Orban, Iii et al.
			8,201,721 B2	6/2012	Zemlok et al.
			8,205,781 B2	6/2012	Baxter, III et al.
			8,210,414 B2	7/2012	Bettuchi et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,211,125 B2	7/2012	Spivey	2007/0027472 A1	2/2007	Hiles et al.
8,225,799 B2	7/2012	Bettuchi	2007/0034668 A1	2/2007	Holsten et al.
8,245,901 B2	8/2012	Stopek	2007/0073341 A1	3/2007	Smith
8,256,654 B2	9/2012	Bettuchi et al.	2007/0084897 A1	4/2007	Shelton, IV et al.
8,257,391 B2	9/2012	Orban, III et al.	2007/0102472 A1	5/2007	Shelton, IV
8,276,802 B2	10/2012	Kostrzewski	2007/0106317 A1	5/2007	Shelton, IV et al.
8,292,155 B2	10/2012	Shelton, IV et al.	2007/0114261 A1	5/2007	Ortiz et al.
8,333,313 B2	12/2012	Boudreaux et al.	2007/0118175 A1	5/2007	Butler et al.
8,348,127 B2	1/2013	Marczyk	2007/0170225 A1	7/2007	Shelton, IV et al.
8,372,094 B2	2/2013	Bettuchi et al.	2007/0175949 A1	8/2007	Shelton, IV et al.
2002/0117534 A1	8/2002	Green et al.	2007/0175950 A1	8/2007	Shelton, IV et al.
2003/0023316 A1	1/2003	Brown et al.	2007/0175951 A1	8/2007	Shelton, IV et al.
2003/0220660 A1	11/2003	Kortenbach et al.	2007/0175953 A1	8/2007	Shelton, IV et al.
2004/0006372 A1	1/2004	Racenet et al.	2007/0175955 A1	8/2007	Shelton, IV et al.
2004/0034369 A1	2/2004	Sauer et al.	2007/0181632 A1	8/2007	Milliman
2004/0044364 A1	3/2004	DeVries et al.	2007/0194079 A1	8/2007	Hueil et al.
2004/0093024 A1	5/2004	Lousararian et al.	2007/0194081 A1	8/2007	Hueil et al.
2004/0094597 A1	5/2004	Whitman et al.	2007/0194082 A1	8/2007	Morgan et al.
2004/0097987 A1	5/2004	Pugsley et al.	2007/0203510 A1	8/2007	Bettuchi
2004/0108357 A1	6/2004	Milliman et al.	2007/0221700 A1	9/2007	Ortiz et al.
2004/0164123 A1	8/2004	Racenet et al.	2007/0221701 A1	9/2007	Ortiz et al.
2004/0167572 A1	8/2004	Roth et al.	2007/0225562 A1	9/2007	Spivey et al.
2004/0173659 A1	9/2004	Green et al.	2007/0239028 A1	10/2007	Houser et al.
2004/0193189 A1	9/2004	Kortenbach et al.	2007/0243227 A1	10/2007	Gertner
2004/0222268 A1	11/2004	Bilotti et al.	2007/0246505 A1	10/2007	Pace-Florida et al.
2004/0232201 A1	11/2004	Wenchell et al.	2007/0260278 A1	11/2007	Wheeler et al.
2004/0243151 A1	12/2004	Demmy et al.	2007/0270884 A1	11/2007	Smith et al.
2004/0254608 A1	12/2004	Huitema et al.	2007/0286892 A1	12/2007	Herzberg et al.
2004/0260315 A1	12/2004	Dell et al.	2007/0295780 A1	12/2007	Shelton et al.
2004/0267310 A1	12/2004	Racenet et al.	2008/0015598 A1	1/2008	Prommersberger
2005/0059997 A1	3/2005	Bauman et al.	2008/0029570 A1	2/2008	Shelton et al.
2005/0070929 A1	3/2005	Dalessandro et al.	2008/0029573 A1	2/2008	Shelton et al.
2005/0080454 A1	4/2005	Drews et al.	2008/0029574 A1	2/2008	Shelton et al.
2005/0090817 A1*	4/2005	Phan 606/41	2008/0029575 A1	2/2008	Shelton et al.
2005/0103819 A1	5/2005	Racenet et al.	2008/0035701 A1	2/2008	Racenet et al.
2005/0119669 A1	6/2005	Demmy	2008/0041917 A1	2/2008	Racenet et al.
2005/0125009 A1	6/2005	Perry et al.	2008/0046000 A1*	2/2008	Lee et al. 606/205
2005/0143759 A1	6/2005	Kelly	2008/0078800 A1	4/2008	Hess et al.
2005/0145675 A1	7/2005	Hartwick et al.	2008/0078802 A1	4/2008	Hess et al.
2005/0177181 A1	8/2005	Kagan et al.	2008/0078803 A1	4/2008	Shelton et al.
2005/0184121 A1	8/2005	Heinrich	2008/0078804 A1	4/2008	Shelton et al.
2005/0187576 A1	8/2005	Whitman et al.	2008/0078806 A1	4/2008	Omaits et al.
2005/0189397 A1	9/2005	Jankowski	2008/0078807 A1	4/2008	Hess et al.
2005/0192628 A1	9/2005	Viola	2008/0078808 A1	4/2008	Hess et al.
2005/0203550 A1	9/2005	Laufer et al.	2008/0082114 A1	4/2008	McKenna et al.
2005/0216055 A1	9/2005	Scirica et al.	2008/0082125 A1	4/2008	Murray et al.
2005/0240222 A1	10/2005	Shipp	2008/0082126 A1	4/2008	Murray et al.
2005/0245965 A1	11/2005	Orban, III et al.	2008/0083813 A1	4/2008	Zemlok et al.
2005/0263563 A1	12/2005	Racenet et al.	2008/0128469 A1	6/2008	Dalessandro et al.
2005/0272978 A1*	12/2005	Brunnen et al. 600/142	2008/0140115 A1	6/2008	Stopek
2005/0274768 A1	12/2005	Cummins et al.	2008/0167522 A1	7/2008	Giordano et al.
2006/0004407 A1	1/2006	Hiles et al.	2008/0167672 A1	7/2008	Giordano et al.
2006/0011699 A1	1/2006	Olson et al.	2008/0169328 A1	7/2008	Shelton
2006/0020336 A1	1/2006	Liddicoat	2008/0169329 A1	7/2008	Shelton et al.
2006/0025811 A1*	2/2006	Shelton, IV 606/205	2008/0169330 A1	7/2008	Shelton et al.
2006/0047307 A1	3/2006	Ortiz et al.	2008/0169331 A1	7/2008	Shelton et al.
2006/0049229 A1	3/2006	Milliman et al.	2008/0169332 A1	7/2008	Shelton et al.
2006/0052825 A1	3/2006	Ransick et al.	2008/0169333 A1	7/2008	Shelton et al.
2006/0085031 A1	4/2006	Bettuchi	2008/0172087 A1	7/2008	Fuchs et al.
2006/0085033 A1	4/2006	Criscuolo et al.	2008/0172088 A1	7/2008	Smith et al.
2006/0100643 A1	5/2006	Laufer et al.	2008/0185419 A1	8/2008	Smith et al.
2006/0108393 A1	5/2006	Heinrich et al.	2008/0197167 A1	8/2008	Viola et al.
2006/0161185 A1	7/2006	Saadat et al.	2008/0200949 A1	8/2008	Hiles et al.
2006/0173470 A1	8/2006	Oray et al.	2008/0237296 A1	10/2008	Boudreaux et al.
2006/0180634 A1	8/2006	Shelton, IV et al.	2008/0251568 A1	10/2008	Zemlok et al.
2006/0226196 A1	10/2006	Hueil et al.	2008/0251569 A1	10/2008	Smith et al.
2006/0235469 A1	10/2006	Viola	2008/0283570 A1	11/2008	Boyden et al.
2006/0241692 A1	10/2006	McGuckin, Jr. et al.	2008/0290134 A1	11/2008	Bettuchi et al.
2006/0253069 A1	11/2006	Li et al.	2008/0296346 A1	12/2008	Shelton, IV et al.
2006/0278680 A1	12/2006	Viola et al.	2008/0300580 A1	12/2008	Shelton, IV et al.
2006/0278681 A1	12/2006	Viola et al.	2008/0308602 A1	12/2008	Timm et al.
2006/0289602 A1	12/2006	Wales et al.	2008/0308603 A1	12/2008	Shelton, IV et al.
2006/0291981 A1	12/2006	Viola et al.	2008/0308608 A1	12/2008	Prommersberger
2007/0023476 A1	2/2007	Whitman et al.	2008/0314960 A1	12/2008	Marczyk et al.
2007/0023477 A1	2/2007	Whitman et al.	2009/0001121 A1	1/2009	Hess et al.
			2009/0001122 A1	1/2009	Prommersberger et al.
			2009/0001124 A1	1/2009	Hess et al.
			2009/0001130 A1	1/2009	Hess et al.
			2009/0005807 A1	1/2009	Hess et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2009/0005808	A1	1/2009	Hess et al.	2011/0006103	A1	1/2011	Laurent et al.
2009/0005809	A1	1/2009	Hess et al.	2011/0011914	A1	1/2011	Baxter, III et al.
2009/0012556	A1	1/2009	Boudreaux et al.	2011/0011915	A1	1/2011	Shelton, IV
2009/0057369	A1	3/2009	Smith et al.	2011/0017801	A1	1/2011	Zemlok et al.
2009/0076534	A1	3/2009	Shelton, IV et al.	2011/0024477	A1	2/2011	Hall
2009/0078736	A1	3/2009	Van Lue	2011/0024478	A1	2/2011	Shelton, IV
2009/0108048	A1	4/2009	Zemlok et al.	2011/0024479	A1	2/2011	Swensgard et al.
2009/0114701	A1	5/2009	Zemlok et al.	2011/0036887	A1	2/2011	Zemlok et al.
2009/0149871	A9	6/2009	Kagan et al.	2011/0042441	A1	2/2011	Shelton, IV et al.
2009/0206125	A1	8/2009	Huitema et al.	2011/0060363	A1	3/2011	Hess et al.
2009/0206126	A1	8/2009	Huitema et al.	2011/0062212	A1	3/2011	Shelton, IV et al.
2009/0206131	A1	8/2009	Weisenburgh, II et al.	2011/0068145	A1	3/2011	Bedi et al.
2009/0206132	A1	8/2009	Huell et al.	2011/0068148	A1	3/2011	Hall et al.
2009/0206133	A1	8/2009	Morgan et al.	2011/0084112	A1	4/2011	Kostrzewski
2009/0206137	A1	8/2009	Hall et al.	2011/0084113	A1	4/2011	Bedi et al.
2009/0206139	A1	8/2009	Hall et al.	2011/0084115	A1	4/2011	Bedi et al.
2009/0206141	A1	8/2009	Huitema et al.	2011/0087276	A1	4/2011	Bedi et al.
2009/0206142	A1	8/2009	Huitema et al.	2011/0087279	A1	4/2011	Shah et al.
2009/0206143	A1	8/2009	Huitema et al.	2011/0095068	A1	4/2011	Patel
2009/0209946	A1	8/2009	Swayze et al.	2011/0101065	A1	5/2011	Milliman
2009/0209990	A1	8/2009	Yates et al.	2011/0114697	A1	5/2011	Baxter, III et al.
2009/0218384	A1	9/2009	Aranyi	2011/0114698	A1	5/2011	Baxter, III et al.
2009/0242610	A1	10/2009	Shelton, IV et al.	2011/0114699	A1	5/2011	Baxter, III et al.
2009/0255974	A1	10/2009	Viola	2011/0114700	A1	5/2011	Baxter, III et al.
2009/0255975	A1	10/2009	Zemlok et al.	2011/0118761	A1	5/2011	Baxter, III et al.
2009/0255976	A1	10/2009	Marczyk et al.	2011/0121051	A1	5/2011	Shelton, IV et al.
2009/0255977	A1	10/2009	Zemlok	2011/0121052	A1	5/2011	Shelton, IV et al.
2009/0255978	A1	10/2009	Viola et al.	2011/0125176	A1	5/2011	Yates et al.
2010/0012704	A1	1/2010	Tarinelli Racenet et al.	2011/0125177	A1	5/2011	Yates et al.
2010/0032470	A1	2/2010	Hess et al.	2011/0132962	A1	6/2011	Hall et al.
2010/0065605	A1	3/2010	Shelton, IV et al.	2011/0132963	A1	6/2011	Giordano et al.
2010/0069942	A1	3/2010	Shelton, IV	2011/0132964	A1	6/2011	Weisenburgh, II et al.
2010/0072254	A1	3/2010	Aranyi et al.	2011/0132965	A1	6/2011	Moore et al.
2010/0076474	A1	3/2010	Yates et al.	2011/0139852	A1	6/2011	Zingman
2010/0076475	A1	3/2010	Yates et al.	2011/0144430	A1	6/2011	Spivey et al.
2010/0089970	A1	4/2010	Smith et al.	2011/0147433	A1	6/2011	Shelton, IV et al.
2010/0089972	A1	4/2010	Marczyk	2011/0147434	A1	6/2011	Hueil et al.
2010/0089974	A1	4/2010	Shelton, IV	2011/0155780	A1	6/2011	Boudreaux
2010/0108740	A1	5/2010	Pastorelli et al.	2011/0155781	A1	6/2011	Swensgard et al.
2010/0108741	A1	5/2010	Hessler et al.	2011/0155785	A1	6/2011	Laurent et al.
2010/0127042	A1	5/2010	Shelton, IV	2011/0155787	A1	6/2011	Baxter, III et al.
2010/0133317	A1	6/2010	Shelton, IV et al.	2011/0163147	A1	7/2011	Laurent et al.
2010/0133318	A1	6/2010	Boudreaux	2011/0174860	A1	7/2011	Shelton, IV et al.
2010/0147922	A1	6/2010	Olson	2011/0174861	A1	7/2011	Shelton, IV et al.
2010/0163598	A1	7/2010	Belzer	2011/0174863	A1	7/2011	Shelton, IV et al.
2010/0179382	A1	7/2010	Shelton, IV et al.	2011/0178536	A1	7/2011	Kostrzewski
2010/0181364	A1	7/2010	Shelton, IV et al.	2011/0192882	A1	8/2011	Hess et al.
2010/0193566	A1	8/2010	Scheib et al.	2011/0210156	A1	9/2011	Smith et al.
2010/0193567	A1	8/2010	Scheib et al.	2011/0226837	A1	9/2011	Baxter, III et al.
2010/0193568	A1	8/2010	Scheib et al.	2011/0275901	A1	11/2011	Shelton, IV
2010/0193569	A1	8/2010	Yates et al.	2011/0276083	A1	11/2011	Shelton, IV et al.
2010/0198220	A1	8/2010	Boudreaux et al.	2011/0278343	A1	11/2011	Knodel et al.
2010/0200637	A1	8/2010	Beetel	2011/0288573	A1	11/2011	Yates et al.
2010/0213241	A1	8/2010	Bedi et al.	2011/0290851	A1	12/2011	Shelton, IV
2010/0222901	A1	9/2010	Swayze et al.	2011/0290853	A1	12/2011	Shelton, IV et al.
2010/0224669	A1	9/2010	Shelton, IV et al.	2011/0290854	A1	12/2011	Timm et al.
2010/0230465	A1	9/2010	Smith et al.	2011/0290855	A1	12/2011	Moore et al.
2010/0237132	A1	9/2010	Measamer et al.	2011/0290856	A1	12/2011	Shelton, IV et al.
2010/0243707	A1	9/2010	Olson et al.	2011/0295242	A1	12/2011	Spivey et al.
2010/0243708	A1	9/2010	Aranyi et al.	2011/0295269	A1	12/2011	Swensgard et al.
2010/0243709	A1	9/2010	Hess et al.	2011/0295270	A1	12/2011	Giordano et al.
2010/0258611	A1	10/2010	Smith et al.	2011/0295295	A1	12/2011	Shelton, IV et al.
2010/0264193	A1	10/2010	Huang et al.	2012/0024934	A1	2/2012	Shelton, IV et al.
2010/0264194	A1	10/2010	Huang et al.	2012/0024935	A1	2/2012	Shelton, IV et al.
2010/0276471	A1	11/2010	Whitman	2012/0024936	A1	2/2012	Baxter, III et al.
2010/0294827	A1	11/2010	Boyden et al.	2012/0029272	A1	2/2012	Shelton, IV et al.
2010/0294829	A1	11/2010	Giordano et al.	2012/0029544	A1	2/2012	Shelton, IV et al.
2010/0301095	A1	12/2010	Shelton, IV et al.	2012/0029547	A1	2/2012	Shelton, IV et al.
2010/0301096	A1	12/2010	Moore et al.	2012/0046692	A1	2/2012	Smith et al.
2010/0305552	A1	12/2010	Shelton, IV et al.	2012/0061448	A1	3/2012	Zingman
2010/0308100	A1	12/2010	Boudreaux	2012/0071711	A1	3/2012	Shelton, IV et al.
2010/0312261	A1	12/2010	Suzuki et al.	2012/0071866	A1	3/2012	Kerr et al.
2010/0331880	A1	12/2010	Stopek	2012/0074196	A1	3/2012	Shelton, IV et al.
2011/0006099	A1	1/2011	Hall et al.	2012/0074198	A1	3/2012	Huitema et al.
2011/0006101	A1	1/2011	Hall et al.	2012/0074200	A1	3/2012	Schmid et al.
				2012/0074201	A1	3/2012	Baxter, III et al.
				2012/0080332	A1	4/2012	Shelton, IV et al.
				2012/0080333	A1	4/2012	Woodard, Jr. et al.
				2012/0080334	A1	4/2012	Shelton, IV et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2012/0080335 A1 4/2012 Shelton, IV et al.
 2012/0080336 A1 4/2012 Shelton, IV et al.
 2012/0080337 A1 4/2012 Shelton, IV et al.
 2012/0080338 A1 4/2012 Shelton, IV et al.
 2012/0080339 A1 4/2012 Shelton, IV et al.
 2012/0080340 A1 4/2012 Shelton, IV et al.
 2012/0080344 A1 4/2012 Shelton, IV
 2012/0080345 A1 4/2012 Morgan et al.
 2012/0080475 A1 4/2012 Smith et al.
 2012/0080477 A1 4/2012 Leimbach et al.
 2012/0080478 A1 4/2012 Morgan et al.
 2012/0080479 A1 4/2012 Shelton, IV
 2012/0080480 A1 4/2012 Woodard, Jr. et al.
 2012/0080481 A1 4/2012 Widenhouse et al.
 2012/0080482 A1 4/2012 Schall et al.
 2012/0080483 A1 4/2012 Riestenberg et al.
 2012/0080484 A1 4/2012 Morgan et al.
 2012/0080485 A1 4/2012 Woodard, Jr. et al.
 2012/0080486 A1 4/2012 Woodard, Jr. et al.
 2012/0080487 A1 4/2012 Woodard, Jr. et al.
 2012/0080488 A1 4/2012 Shelton, IV et al.
 2012/0080489 A1 4/2012 Shelton, IV et al.
 2012/0080490 A1 4/2012 Shelton, IV et al.
 2012/0080491 A1 4/2012 Shelton, IV et al.
 2012/0080493 A1 4/2012 Shelton, IV et al.
 2012/0080498 A1 4/2012 Shelton, IV et al.
 2012/0080499 A1 4/2012 Schall et al.
 2012/0080500 A1 4/2012 Morgan et al.
 2012/0080501 A1 4/2012 Morgan et al.
 2012/0080502 A1 4/2012 Morgan et al.
 2012/0080503 A1 4/2012 Woodard, Jr. et al.
 2012/0083833 A1 4/2012 Shelton, IV et al.
 2012/0083834 A1 4/2012 Shelton, IV et al.
 2012/0083835 A1 4/2012 Shelton, IV et al.
 2012/0083836 A1 4/2012 Shelton, IV et al.
 2012/0132450 A1 5/2012 Timm et al.
 2012/0138658 A1 6/2012 Ullrich et al.
 2012/0138660 A1 6/2012 Shelton, IV
 2012/0160721 A1 6/2012 Shelton, IV et al.
 2012/0175399 A1 7/2012 Shelton et al.
 2012/0187179 A1 7/2012 Gleiman
 2012/0199630 A1 8/2012 Shelton, IV et al.
 2012/0199631 A1 8/2012 Shelton, IV et al.
 2012/0199632 A1 8/2012 Spivey et al.
 2012/0199633 A1 8/2012 Shelton, IV et al.
 2012/0203247 A1 8/2012 Shelton, IV et al.
 2012/0205421 A1 8/2012 Shelton, IV
 2012/0211546 A1 8/2012 Shelton, IV
 2012/0234890 A1 9/2012 Aronhalt et al.
 2012/0234891 A1 9/2012 Aronhalt et al.
 2012/0234892 A1 9/2012 Aronhalt et al.
 2012/0234893 A1 9/2012 Schuckmann et al.
 2012/0234895 A1 9/2012 O'Connor et al.
 2012/0234896 A1 9/2012 Ellerhorst et al.
 2012/0234897 A1 9/2012 Shelton, IV et al.
 2012/0234898 A1 9/2012 Shelton, IV et al.
 2012/0234899 A1 9/2012 Scheib et al.
 2012/0234900 A1 9/2012 Swayze
 2012/0238823 A1 9/2012 Hagerty et al.
 2012/0238824 A1 9/2012 Widenhouse et al.
 2012/0238826 A1 9/2012 Yoo et al.
 2012/0238829 A1 9/2012 Shelton, IV et al.
 2012/0239009 A1 9/2012 Mollere et al.
 2012/0239010 A1 9/2012 Shelton, IV et al.
 2012/0239012 A1 9/2012 Laurent et al.
 2012/0239075 A1 9/2012 Widenhouse et al.
 2012/0239082 A1 9/2012 Shelton, IV et al.
 2012/0241491 A1 9/2012 Aldridge et al.
 2012/0241492 A1 9/2012 Shelton, IV et al.
 2012/0241493 A1 9/2012 Baxter, III et al.
 2012/0241496 A1 9/2012 Mandakolathur Vasudevan et al.
 2012/0241497 A1 9/2012 Mandakolathur Vasudevan et al.
 2012/0241498 A1 9/2012 Gonzalez et al.
 2012/0241499 A1 9/2012 Baxter, III et al.
 2012/0241500 A1 9/2012 Timmer et al.

2012/0241501 A1 9/2012 Swayze et al.
 2012/0241502 A1 9/2012 Aldridge et al.
 2012/0241503 A1 9/2012 Baxter, III et al.
 2012/0241505 A1 9/2012 Alexander, III et al.
 2012/0248169 A1 10/2012 Widenhouse et al.
 2012/0253298 A1 10/2012 Henderson et al.
 2012/0265230 A1 10/2012 Yates et al.
 2012/0273551 A1 11/2012 Shelton, IV et al.
 2012/0283707 A1 11/2012 Giordano et al.
 2012/0286019 A1 11/2012 Hueil et al.
 2012/0292367 A1 11/2012 Morgan et al.
 2012/0292370 A1 11/2012 Hess et al.
 2012/0298719 A1 11/2012 Shelton, IV et al.
 2012/0325892 A1 12/2012 Kostorzewski
 2013/0012931 A1 1/2013 Spivey et al.
 2013/0012957 A1 1/2013 Shelton, IV et al.
 2013/0020376 A1 1/2013 Shelton, IV et al.
 2013/0023861 A1 1/2013 Shelton, IV et al.
 2013/0026208 A1 1/2013 Shelton, IV et al.
 2013/0026210 A1 1/2013 Shelton, IV et al.
 2013/0037596 A1 2/2013 Bear et al.
 2013/0041371 A1 2/2013 Yates et al.
 2013/0048697 A1 2/2013 Shelton, IV et al.
 2013/0056518 A1 3/2013 Swensgard
 2013/0056520 A1 3/2013 Swensgard
 2013/0056521 A1 3/2013 Swensgard
 2013/0056522 A1 3/2013 Swensgard
 2013/0075443 A1 3/2013 Giordano et al.
 2013/0075448 A1 3/2013 Schmid et al.
 2013/0075449 A1 3/2013 Schmid et al.
 2013/0075450 A1 3/2013 Schmid et al.

FOREIGN PATENT DOCUMENTS

CA 2514274 A1 1/2006
 CN 2488482 Y 5/2002
 CN 1634601 A 7/2005
 CN 1868411 A 11/2006
 CN 1915180 A 2/2007
 CN 101011286 A 8/2007
 CN 101095621 A 1/2008
 DE 273689 C 5/1914
 DE 1775926 A 1/1972
 DE 3036217 A1 4/1982
 DE 3210466 A1 9/1983
 DE 3709067 A1 9/1988
 DE 9412228 U 9/1994
 DE 19509116 A1 9/1996
 DE 19851291 A1 1/2000
 DE 1992431.1 A1 11/2000
 DE 69328576 T2 1/2001
 DE 10052679 A1 5/2001
 DE 20112937 U1 10/2001
 DE 20121753 U1 4/2003
 DE 10314072 A1 10/2004
 DE 202007003114 U1 6/2007
 EP 0122046 A1 10/1984
 EP 0070230 B1 10/1985
 EP 0156774 A2 10/1985
 EP 0387980 B1 10/1985
 EP 0033548 B1 5/1986
 EP 0129442 B1 11/1987
 EP 0276104 A2 7/1988
 EP 0178940 B1 1/1991
 EP 0178941 B1 1/1991
 EP 0248844 B1 1/1993
 EP 0545029 A1 6/1993
 EP 0277959 B1 10/1993
 EP 0233940 B1 11/1993
 EP 0261230 B1 11/1993
 EP 0639349 A2 2/1994
 EP 0324636 B1 3/1994
 EP 0593920 A1 4/1994
 EP 0594148 A1 4/1994
 EP 0427949 B1 6/1994
 EP 0523174 B1 6/1994
 EP 0600182 A2 6/1994
 EP 0310431 B1 11/1994
 EP 0375302 B1 11/1994

(56)

References Cited

FOREIGN PATENT DOCUMENTS

EP	0376562	B1	11/1994	EP	0829235	B1	6/2003
EP	0630612	A1	12/1994	EP	0687046	B1	7/2003
EP	0634144	A1	1/1995	EP	0852480	B1	8/2003
EP	0646356	A2	4/1995	EP	0691154	B1	9/2003
EP	0646357	A1	4/1995	EP	0813843	B1	10/2003
EP	0653189	A2	5/1995	EP	0873089	B1	10/2003
EP	0669104	A1	8/1995	EP	0856326	B1	11/2003
EP	0511470	B1	10/1995	EP	1374788	A1	1/2004
EP	0679367	A2	11/1995	EP	0741996	B1	2/2004
EP	0392547	B1	12/1995	EP	0814712	B1	2/2004
EP	0685204	A1	12/1995	EP	1402837	A1	3/2004
EP	0364216	B1	1/1996	EP	0705570	B1	4/2004
EP	0699418	A1	3/1996	EP	0959784	B1	4/2004
EP	0702937	A1	3/1996	EP	1407719	A2	4/2004
EP	0705571	A1	4/1996	EP	1086713	B1	5/2004
EP	0711611	A2	5/1996	EP	0996378	B1	6/2004
EP	0484677	B2	6/1996	EP	1426012	A1	6/2004
EP	0541987	B1	7/1996	EP	0833593	B2	7/2004
EP	0667119	B1	7/1996	EP	1442694	A1	8/2004
EP	0708618	B1	3/1997	EP	0688749	B1	9/2004
EP	0770355	A1	5/1997	EP	0959786	B1	9/2004
EP	0503662	B1	6/1997	EP	1459695	A1	9/2004
EP	0447121	B1	7/1997	EP	1473819	A1	11/2004
EP	0625077	B1	7/1997	EP	1477119	A1	11/2004
EP	0633749	B1	8/1997	EP	1479345	A1	11/2004
EP	0710090	B1	8/1997	EP	1479347	A1	11/2004
EP	0578425	B1	9/1997	EP	1479348	A1	11/2004
EP	0625335	B1	11/1997	EP	0754437	B2	12/2004
EP	0552423	B1	1/1998	EP	1025807	B1	12/2004
EP	0592244	B1	1/1998	EP	1001710	B1	1/2005
EP	0648476	B1	1/1998	EP	1520521	A1	4/2005
EP	0649290	B1	3/1998	EP	1520523	A1	4/2005
EP	0598618	B1	9/1998	EP	1520525	A1	4/2005
EP	0676173	B1	9/1998	EP	1522264	A1	4/2005
EP	0678007	B1	9/1998	EP	1523942	A2	4/2005
EP	0603472	B1	11/1998	EP	1550408	A1	7/2005
EP	0605351	B1	11/1998	EP	1557129	A1	7/2005
EP	0878169	A1	11/1998	EP	1064883	B1	8/2005
EP	0879742	A1	11/1998	EP	1067876	B1	8/2005
EP	0695144	B1	12/1998	EP	0870473	B1	9/2005
EP	0722296	B1	12/1998	EP	1157666	B1	9/2005
EP	0760230	B1	2/1999	EP	0880338	B1	10/2005
EP	0623316	B1	3/1999	EP	1158917	B1	11/2005
EP	0650701	B1	3/1999	EP	1330989	B1	12/2005
EP	0537572	B1	6/1999	EP	0771176	B2	1/2006
EP	0923907	A1	6/1999	EP	1621138	A2	2/2006
EP	0843906	B1	3/2000	EP	1621139	A2	2/2006
EP	0552050	B1	5/2000	EP	1621141	A2	2/2006
EP	0833592	B1	5/2000	EP	1621145	A2	2/2006
EP	0830094	B1	9/2000	EP	1621151	A2	2/2006
EP	1034747	A1	9/2000	EP	1034746	B1	3/2006
EP	1034748	A1	9/2000	EP	1632191	A2	3/2006
EP	0694290	B1	11/2000	EP	1065981	B1	5/2006
EP	1050278	A1	11/2000	EP	1082944	B1	5/2006
EP	1053719	A1	11/2000	EP	1652481	A2	5/2006
EP	1053720	A1	11/2000	EP	1382303	B1	6/2006
EP	1055399	A1	11/2000	EP	1253866	B1	7/2006
EP	1055400	A1	11/2000	EP	1032318	B1	8/2006
EP	1080694	A1	3/2001	EP	1045672	81	8/2006
EP	1090592	A1	4/2001	EP	1617768	B1	8/2006
EP	1095627	A1	5/2001	EP	1693015	A2	8/2006
EP	1256318	B1	5/2001	EP	1400214	B1	9/2006
EP	0806914	B1	9/2001	EP	1702567	A2	9/2006
EP	0768840	B1	12/2001	EP	1129665	B1	11/2006
EP	0908152	B1	1/2002	EP	1400206	B1	11/2006
EP	0872213	B1	5/2002	EP	1721568	A1	11/2006
EP	0862386	B1	6/2002	EP	1255317	B1	12/2006
EP	0949886	B1	9/2002	EP	1285633	B1	12/2006
EP	1238634	A2	9/2002	EP	1728473	A1	12/2006
EP	0858295	B1	12/2002	EP	1728475	A2	12/2006
EP	0656188	B1	1/2003	EP	1479346	B1	1/2007
EP	1284120	A1	2/2003	EP	1484024	B1	1/2007
EP	1287788	A1	3/2003	EP	1754445	A2	2/2007
EP	0717966	B1	4/2003	EP	1759812	A1	3/2007
EP	0869742	B1	5/2003	EP	1769758	A1	4/2007
				EP	1581128	B1	5/2007
				EP	1780825	A1	5/2007
				EP	1785097	A2	5/2007
				EP	1790293	A2	5/2007

(56)

References Cited

FOREIGN PATENT DOCUMENTS

EP	1800610	A1	6/2007	GB	1210522	A	10/1970
EP	1300117	B1	8/2007	GB	1217159	A	12/1970
EP	1813199	A1	8/2007	GB	1339394	A	12/1973
EP	1813201	A1	8/2007	GB	2109241	A	6/1983
EP	1813202	A1	8/2007	GB	2272159	A	5/1994
EP	1813203	A2	8/2007	GB	2284242	A	5/1995
EP	1813207	A1	8/2007	GB	2336214	A	10/1999
EP	1813209	A1	8/2007	GB	2425903	A	11/2006
EP	1487359	B1	10/2007	JP	50-33988	U	4/1975
EP	1599146	B1	10/2007	JP	58500053	A	1/1983
EP	1839596	A1	10/2007	JP	61-98249	A	5/1986
EP	2110083	A2	10/2007	JP	61502036	A	9/1986
EP	1857057	A2	11/2007	JP	63-203149		8/1988
EP	1402821	B1	12/2007	JP	3-12126	A	1/1991
EP	1872727	A1	1/2008	JP	5-212039	A	8/1993
EP	1897502	A1	3/2008	JP	6007357	A	1/1994
EP	1330201	B1	6/2008	JP	7051273	A	2/1995
EP	1702568	B1	7/2008	JP	7-124166	A	5/1995
EP	1943955	A2	7/2008	JP	7-255735	A	10/1995
EP	1943957	A2	7/2008	JP	8-33642	A	2/1996
EP	1943964	A1	7/2008	JP	8033641	A	2/1996
EP	1943976	A2	7/2008	JP	8-164141	A	6/1996
EP	1593337	B1	8/2008	JP	8229050	A	9/1996
EP	1970014	A1	9/2008	JP	2000033071	A	2/2000
EP	1980213	A2	10/2008	JP	2000171730	A	6/2000
EP	1759645	B1	11/2008	JP	2000287987	A	10/2000
EP	1990014	A2	11/2008	JP	2000325303	A	11/2000
EP	1693008	B1	12/2008	JP	2001-514541	A	9/2001
EP	1759640	B1	12/2008	JP	2001286477	A	10/2001
EP	2000102	A2	12/2008	JP	2002143078	A	5/2002
EP	2005894	A2	12/2008	JP	2002369820	A	12/2002
EP	2008595	A2	12/2008	JP	2003-500153	A	1/2003
EP	1736104	B1	3/2009	JP	2003-521301	A	7/2003
EP	1749486	B1	3/2009	JP	2004-329624	A	11/2004
EP	2039316	A2	3/2009	JP	2004-344663		12/2004
EP	1721576	B1	4/2009	JP	2005-028149	A	2/2005
EP	1733686	B1	4/2009	JP	2005505322	T	2/2005
EP	2044890	A1	4/2009	JP	2005103293	A	4/2005
EP	1550409	A1	6/2009	JP	2005131163	A	5/2005
EP	1550413	B1	6/2009	JP	2005131164	A	5/2005
EP	1745748	B1	8/2009	JP	2005131173	A	5/2005
EP	2090237	A1	8/2009	JP	2005131211	A	5/2005
EP	2090244	A2	8/2009	JP	2005131212	A	5/2005
EP	2090245	A1	8/2009	JP	2005137423	A	6/2005
EP	2090256	A2	8/2009	JP	2005152416	A	6/2005
EP	2095777	A2	9/2009	JP	2005-523105	A	8/2005
EP	2110082	A1	10/2009	JP	2005524474	A	8/2005
EP	1813208	B1	11/2009	JP	2006-034975	A	2/2006
EP	1908426	B1	11/2009	JP	2006-218297	A	8/2006
EP	2116195	A1	11/2009	JP	2006-281405	A	10/2006
EP	1607050	B1	12/2009	JP	2007-117725	A	5/2007
EP	1815804	B1	12/2009	JP	2008-283459	A	11/2008
EP	1813206	B1	4/2010	RU	2008830	C1	3/1994
EP	1535565	B1	10/2010	RU	2141279	C1	11/1999
EP	1702570	B1	10/2010	RU	2187249	C2	8/2002
EP	1785098	B1	10/2010	RU	2225170	C2	3/2004
EP	2005896	B1	10/2010	SU	189517	A	1/1967
EP	2030578	B1	11/2010	SU	326636	A	9/1972
EP	1627605	B1	12/2010	SU	886900	A1	12/1981
EP	1690502	B1	3/2011	SU	1009439	A	4/1983
EP	1813205	B1	6/2011	SU	1333319	A2	8/1987
EP	2090243	B1	6/2011	SU	1377053	A1	2/1988
EP	1785102	B1	1/2012	SU	1561964	A1	5/1990
EP	2005895	B1	8/2012	SU	1708312	A1	1/1992
EP	2090248	B1	8/2012	SU	1722476	A1	3/1992
ER	1344498	B1	11/2005	SU	1752361	A1	8/1992
ER	1767163	A1	3/2007	WO	WO 82/02824	A1	9/1982
ER	1769756	A1	4/2007	WO	WO 91/15157	A1	10/1991
ER	1565150	B1	4/2010	WO	WO 92/20295	A1	11/1992
ER	1769754	B1	6/2010	WO	WO 92/21300	A1	12/1992
FR	999646	A	2/1952	WO	WO 93/08765	A1	5/1993
FR	1112936	A	3/1956	WO	WO 93/13718	A1	7/1993
FR	2598905	A1	11/1987	WO	WO 93/14690	A1	8/1993
FR	2765794	A	1/1999	WO	WO 93/15648	A1	8/1993
GB	939929	A	10/1963	WO	WO 93/15850	A1	8/1993
				WO	WO 93/19681	A1	10/1993
				WO	WO 94/00060	A1	1/1994
				WO	WO 94/11057	A1	5/1994
				WO	WO 94/12108	A1	6/1994

(56)

References Cited

FOREIGN PATENT DOCUMENTS

WO	WO 94/18893	A1	9/1994	WO	WO 00/57796	A1	10/2000
WO	WO 94/22378	A1	10/1994	WO	WO 00/64365	A1	11/2000
WO	WO 94/23659	A1	10/1994	WO	WO 00/72762	A1	12/2000
WO	WO 95/02369	A1	1/1995	WO	WO 00/72765	A1	12/2000
WO	WO 95/03743	A1	2/1995	WO	WO 01/03587	A1	1/2001
WO	WO 95/06817	A1	3/1995	WO	WO 01/05702	A1	1/2001
WO	WO 95/09576	A1	4/1995	WO	WO 01/10482	A1	2/2001
WO	WO 95/09577	A1	4/1995	WO	WO 01/35845	A1	5/2001
WO	WO 95/14436	A1	6/1995	WO	WO 01/54594	A1	8/2001
WO	WO 95/17855	A1	7/1995	WO	WO 01/58371	A1	8/2001
WO	WO 95/18383	A1	7/1995	WO	WO 01/62158	A2	8/2001
WO	WO 95/18572	A1	7/1995	WO	WO 01/62161	A1	8/2001
WO	WO 95/19739	A1	7/1995	WO	WO 01/62162	A1	8/2001
WO	WO 95/20360	A1	8/1995	WO	WO 01/62164	A2	8/2001
WO	WO 95/23557	A1	9/1995	WO	WO 01/62169	A2	8/2001
WO	WO 95/24865	A1	9/1995	WO	WO 01/78605	A2	10/2001
WO	WO 95/25471	A3	9/1995	WO	WO 01/91646	A1	12/2001
WO	WO 95/26562	A1	10/1995	WO	WO 02/07608	A2	1/2002
WO	WO 95/29639	A1	11/1995	WO	WO 02/07618	A1	1/2002
WO	WO 96/04858	A1	2/1996	WO	WO 02/17799	Ai	3/2002
WO	WO 96/19151	A1	6/1996	WO	WO 02/19920	A1	3/2002
WO	WO 96/19152	A1	6/1996	WO	WO 02/19932	A1	3/2002
WO	WO 96/20652	A1	7/1996	WO	WO 02/30297	A2	4/2002
WO	WO 96/21119	A1	7/1996	WO	WO 02/32322	A2	4/2002
WO	WO 96/22055	A1	7/1996	WO	WO 02/36028	A1	5/2002
WO	WO 96/23448	A1	8/1996	WO	WO 02/43571	A2	6/2002
WO	WO 96/24301	A1	8/1996	WO	WO 02/058568	A1	8/2002
WO	WO 96/27337	A1	9/1996	WO	WO 02/060328	A1	8/2002
WO	WO 96/31155	A1	10/1996	WO	WO 02/067785	A2	9/2002
WO	WO 96/35464	A1	11/1996	WO	WO 02/098302	A1	12/2002
WO	WO 96/39085	A1	12/1996	WO	WO 03/000138	A2	1/2003
WO	WO 96/39086	A1	12/1996	WO	WO 03/001329	A2	1/2003
WO	WO 96/39087	A1	12/1996	WO	WO 03/013363	A1	2/2003
WO	WO 96/39088	A1	12/1996	WO	WO 03/015604	A2	2/2003
WO	WO 96/39089	A1	12/1996	WO	WO 03/020106	A2	3/2003
WO	WO 97/00646	A1	1/1997	WO	WO 03/020139	A2	3/2003
WO	WO 97/00647	A1	1/1997	WO	WO 03/024339	A1	3/2003
WO	WO 97/06582	A1	2/1997	WO	WO 03/079909	A3	3/2003
WO	WO 97/10763	A1	3/1997	WO	WO 03/030743	A2	4/2003
WO	WO 97/10764	A1	3/1997	WO	WO 03/037193	A1	5/2003
WO	WO 97/11648	A2	4/1997	WO	WO 03/047436	A3	6/2003
WO	WO 97/11649	A1	4/1997	WO	WO 03/055402	A1	7/2003
WO	WO 97/115237	A1	5/1997	WO	WO 03/057048	A1	7/2003
WO	WO 97/24073	A1	7/1997	WO	WO 03/057058	A1	7/2003
WO	WO 97/24993	A1	7/1997	WO	WO 03/063694	A1	8/2003
WO	WO 97/30644	A1	8/1997	WO	WO 03/077769	A1	9/2003
WO	WO 97/34533	A1	9/1997	WO	WO 03/079911	A1	10/2003
WO	WO 97/37598	A1	10/1997	WO	WO 03/082126	A1	10/2003
WO	WO 97/39688	A2	10/1997	WO	WO 03/088845	A2	10/2003
WO	WO 98/17180	A1	4/1998	WO	WO 03/090630	A2	11/2003
WO	WO 98/27880	A1	7/1998	WO	WO 03/094743	A1	11/2003
WO	WO 98/30153	A1	7/1998	WO	WO 03/094745	A1	11/2003
WO	WO 98/47436	A1	10/1998	WO	WO 03/094746	A1	11/2003
WO	WO 99/03407	A1	1/1999	WO	WO 03/094747	A1	11/2003
WO	WO 99/03408	A1	1/1999	WO	WO 03/101313	A1	12/2003
WO	WO 99/03409	A1	1/1999	WO	WO 03/105698	A2	12/2003
WO	WO 99/12483	A1	3/1999	WO	WO 03/105702	A2	12/2003
WO	WO 99/12487	A1	3/1999	WO	WO 2004/005980	A2	1/2004
WO	WO 99/12488	A1	3/1999	WO	WO 2004/011037	A2	2/2004
WO	WO 99/15086	A1	4/1999	WO	WO 2004/019769	A1	3/2004
WO	WO 99/15091	A1	4/1999	WO	WO 2004/021868	A2	3/2004
WO	WO 99/23933	A2	5/1999	WO	WO 2004/028585	A2	4/2004
WO	WO 99/23959	A1	5/1999	WO	WO 2004/032754	A2	4/2004
WO	WO 99/25261	A1	5/1999	WO	WO 2004/032760	A2	4/2004
WO	WO 99/29244	A1	6/1999	WO	WO 2004/032762	A1	4/2004
WO	WO 99/34744	A1	7/1999	WO	WO 2004/032763	A2	4/2004
WO	WO 99/45849	A1	9/1999	WO	WO 2004/034875	A2	4/2004
WO	WO 99/48430	A1	9/1999	WO	WO 2004/047626	A1	6/2004
WO	WO 99/51158	A1	10/1999	WO	WO 2004/047653	A2	6/2004
WO	WO 00/24322	A1	5/2000	WO	WO 2004/049956	A2	6/2004
WO	WO 00/24330	A1	5/2000	WO	WO 2004/052426	A2	6/2004
WO	WO 00/41638	A1	7/2000	WO	WO 2004/056276	A1	7/2004
WO	WO 00/48506	A1	8/2000	WO	WO 2004/056277	A1	7/2004
WO	WO 00/53112	A2	9/2000	WO	WO 2004/062516	A1	7/2004
WO	WO 00/54653	A1	9/2000	WO	WO 2004/078050	A2	9/2004
				WO	WO 2004/078051	A2	9/2004
				WO	WO 2004/086987	A1	10/2004
				WO	WO 2004/096015	A2	11/2004
				WO	WO 2004/096057	A2	11/2004

(56)

References Cited**FOREIGN PATENT DOCUMENTS**

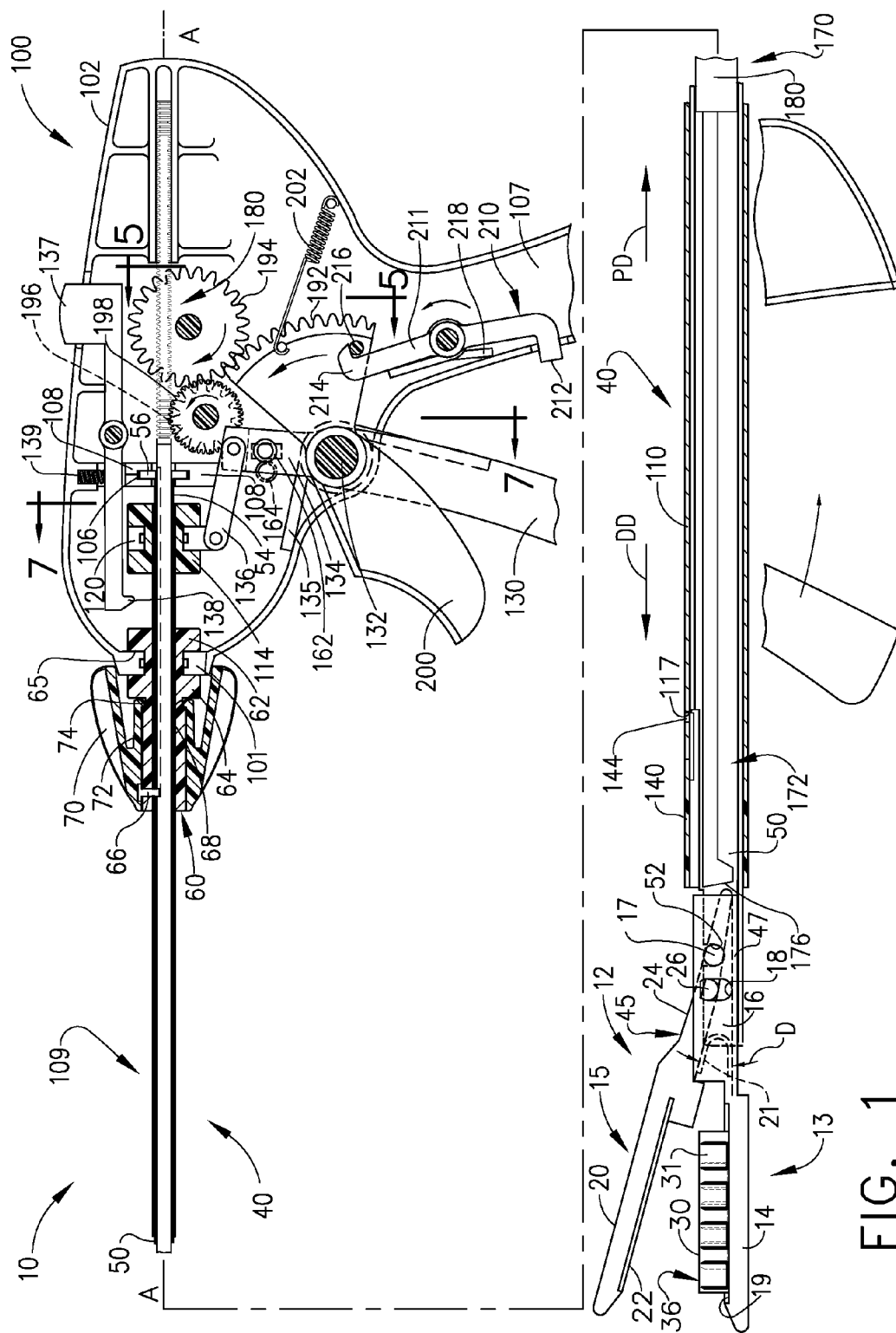
WO WO 2004/103157 A2 12/2004
 WO WO 2004/105593 A1 12/2004
 WO WO 2004/105621 A1 12/2004
 WO WO 2004/112618 A2 12/2004
 WO WO 2004/112652 A2 12/2004
 WO WO 2005/115251 A2 2/2005
 WO WO 2005/027983 A2 3/2005
 WO WO 2005/037329 A2 4/2005
 WO WO 2005/044078 A2 5/2005
 WO WO 2005/055846 A1 6/2005
 WO WO 2005/072634 A2 8/2005
 WO WO 2005/078892 A1 8/2005
 WO WO 2005/079675 A2 9/2005
 WO WO 2005/096954 A2 10/2005
 WO WO 2005/112806 A2 12/2005
 WO WO 2005/112808 A1 12/2005
 WO WO 2005/115253 A2 12/2005
 WO WO 2005/117735 A1 12/2005
 WO WO 2005/122936 A1 12/2005
 WO WO 2006/023486 A1 3/2006
 WO WO 2006/027014 A1 3/2006
 WO WO 2006/044490 A2 4/2006
 WO WO 2006/044581 A2 4/2006
 WO WO 2006/044810 A2 4/2006
 WO WO 2006/051252 A1 5/2006
 WO WO 2006/059067 A1 6/2006
 WO WO 2006/083748 A1 8/2006
 WO WO 2006/1092563 A1 9/2006
 WO WO 2006/1092565 A1 9/2006
 WO WO 2006/125940 A1 11/2006
 WO WO 2006/1115958 A1 11/2006
 WO WO 2006/132992 A1 12/2006
 WO WO 2007/002180 A2 1/2007
 WO WO 2007/016290 A2 2/2007
 WO WO 2007/018898 A2 2/2007
 WO WO 2007/098220 A2 8/2007
 WO WO 2007/121579 A1 11/2007
 WO WO 2007/131110 A2 11/2007
 WO WO 2007/137304 A2 11/2007
 WO WO 2007/139734 A2 12/2007
 WO WO 2007/142625 A2 12/2007
 WO WO 2007/147439 A1 12/2007
 WO WO 2008/021969 A2 2/2008
 WO WO 2008/039249 A1 4/2008
 WO WO 2008/039270 A1 4/2008
 WO WO 2008/045383 A2 4/2008
 WO WO 2008/070763 A1 6/2008
 WO WO 2008/089404 A2 7/2008
 WO WO 2008/101080 A1 8/2008
 WO WO 2008/109125 A1 9/2008
 WO WO 2008/124748 A1 10/2008
 WO WO 2010/030434 A1 3/2010
 WO WO 2010/063795 A1 6/2010
 WO WO 2010/098871 A2 9/2010
 WO WO 2012/021671 A1 2/2012
 WO WO 2012/044844 A2 4/2012

OTHER PUBLICATIONS

U.S. Appl. No. 12/775,699, filed May 7, 2010.
 U.S. Appl. No. 12/894,306, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,360, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,322, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,351, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,339, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,327, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,340, filed Sep. 30, 2010.

U.S. Appl. No. 12/894,350, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,338, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,369, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,312, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,377, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,383, filed Sep. 30, 2010.
 U.S. Appl. No. 12/694,389, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,345, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,318, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,330, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,361, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,367, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,388, filed Sep. 30, 2010.
 U.S. Appl. No. 12/894,376, filed Sep. 30, 2010.
 Disclosed Anonymously, "Motor-Driven Surgical Stapler Improvements," Research Disclosure Database No. 526041, Published: Feb. 2008.
 C.C. Thompson et al., "Peroral Endoscopic Reduction of Dilated Gastrojejunal Anastomosis After Roux-en-Y Gastric Bypass: A Possible New Option for Patients with Weight Regain," Surg Endosc (2006) vol. 20, pp. 1744-1748.
 B.R. Coolman, DVM, MS et al., "Comparison of Skin Staples With Sutures for Anastomosis of the Small Intestine in Dogs," Abstract; <http://www.blackwell-synergy.com/doi/abs/10.1053/jvet.2000.7539?cookieSet=1&journalCode=vsu> which redirects to <http://www3.interscience.wiley.com/journal/119040681/abstract?CRETRY=1&SRETRY=0>; [online] accessed: Sep. 22, 2008 (2 pages).
 The Soderm Aseptic Battery Transfer Kit, Soderm Systems, 2000, 3 pages.
 "Biomedical Coatings," Fort Wayne Metals, Research Products Corporation, obtained online at www.fwmetals.com on Jun. 21, 2010 (1 page).
 Van Meer et al., "A Disposable Plastic Compact Wrist for Smart Minimally Invasive Surgical Tools," LAAS/CNRS (Aug. 2005).
 Breedveld et al., "A New, Easily Miniaturized Sterrable Endoscope," IEEE Engineering in Medicine and Biology Magazine (Nov./Dec. 2005).
 D. Tuite, Ed., "Get the Lowdown on Ultracapacitors," Nov. 15, 2007; [online] URL: <http://electronicdesign.com/Articles/Print.cfm?ArticleID=17465>, accessed Jan. 15, 2008 (5 pages).
 Datasheet for Panasonic TK Relays Ultra Low Profile 2 A Polarized Relay. Copyright Matsushita Electric Works, Ltd. (Known of at least as early as Aug. 17, 2010), 5 pages.
 ASTM procedure D2240-00, "Standard Test Method for Rubber Property-Durometer Hardness," (Published Aug. 2000).
 ASTM procedure D2240-05, "Standard Test Method for Rubber Property-Durometer Hardness," (Published Apr. 2010).
 U.S. Appl. No. 13/242,086, filed Sep. 23, 2011.
 U.S. Appl. No. 13/241,912, filed Sep. 23, 2011.
 U.S. Appl. No. 13/241,922, filed Sep. 23, 2011.
 U.S. Appl. No. 13/433,115, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,118, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,135, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,129, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,140, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,147, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,126, filed Mar. 28, 2012.
 U.S. Appl. No. 13/433,132, filed Mar. 28, 2012.
 International Search Report for PCT/US2011/053087, dated Apr. 12, 2012 (5 pages).
 Written Opinion for PCT/US2011/053087, dated Apr. 12, 2012 (8 pages).

* cited by examiner



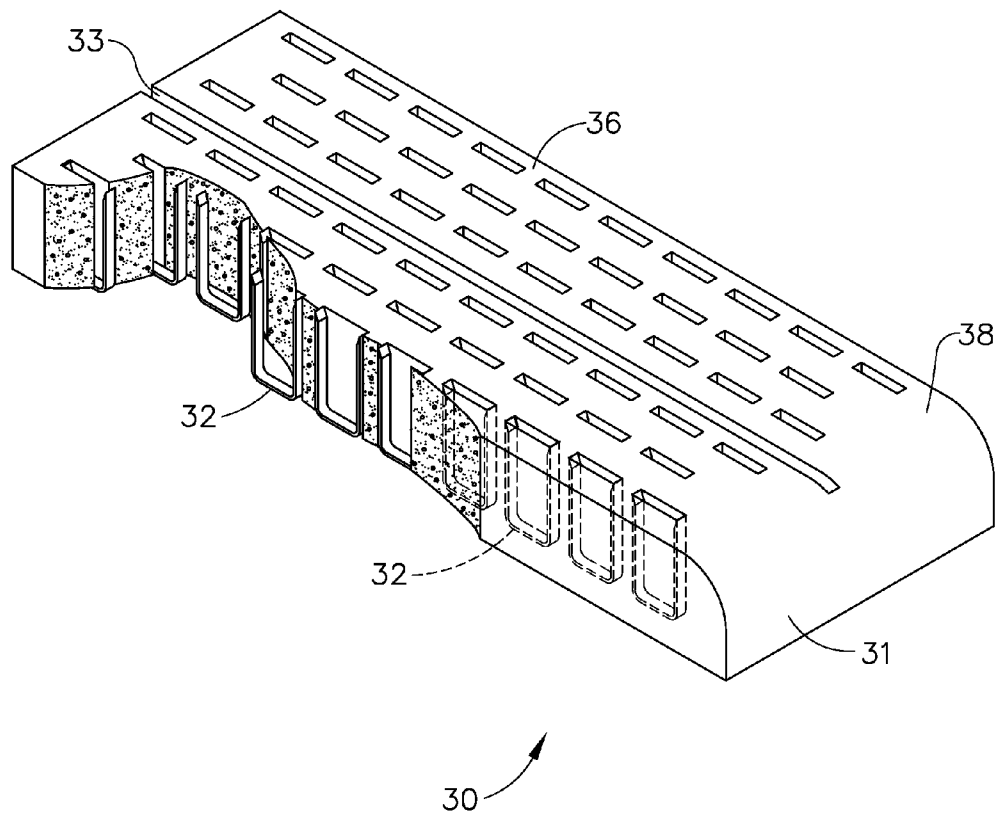


FIG. 1A

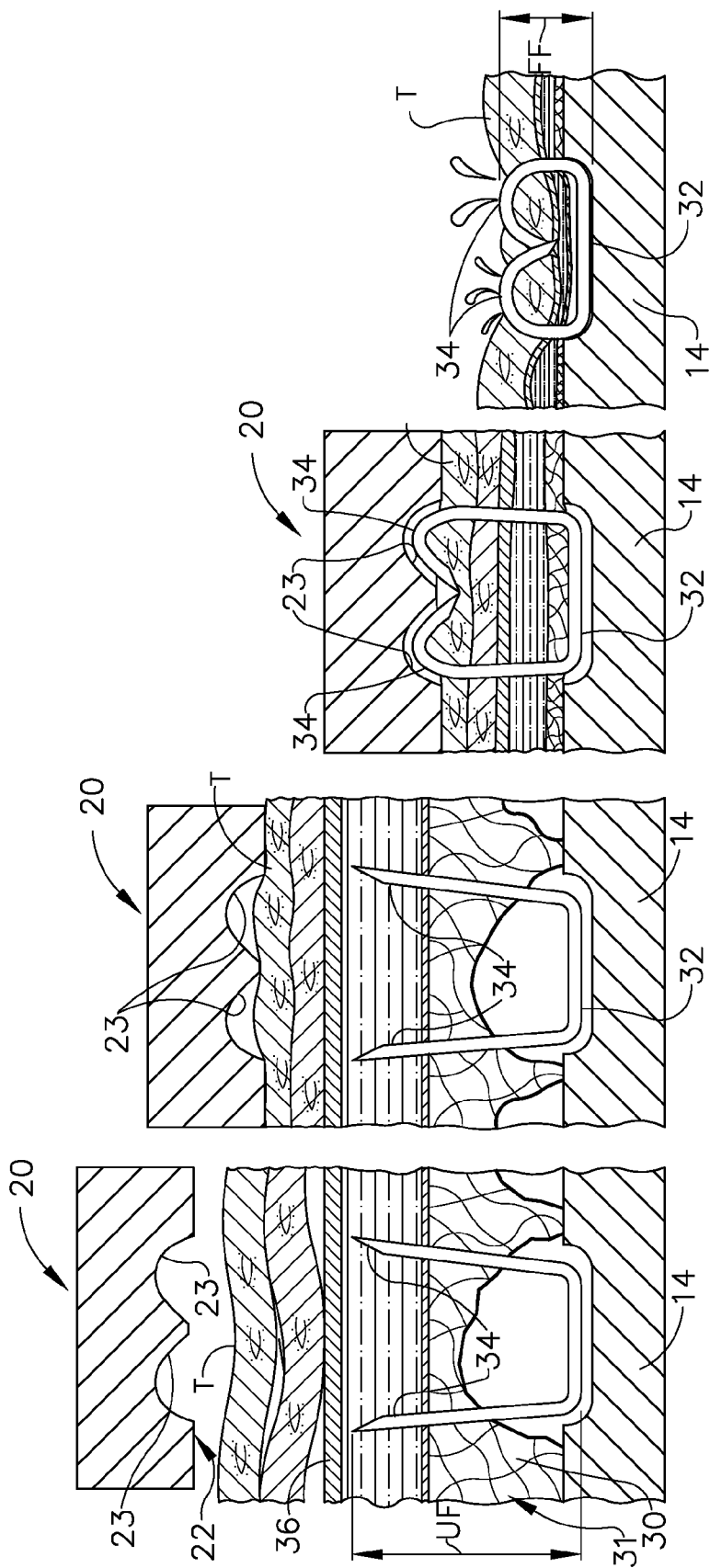


FIG. 1B FIG. 1C FIG. 1D FIG. 1E

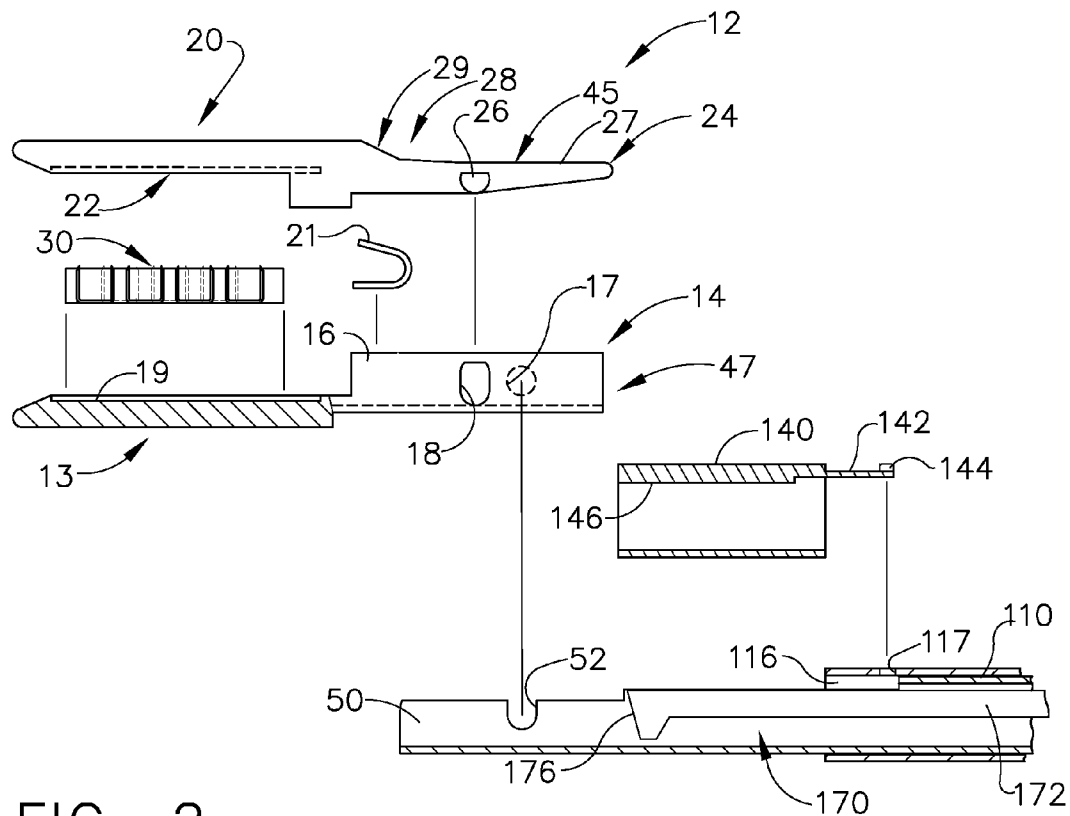


FIG. 2

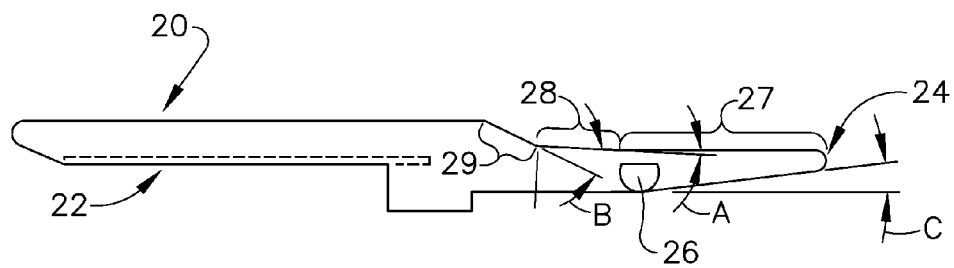


FIG. 3

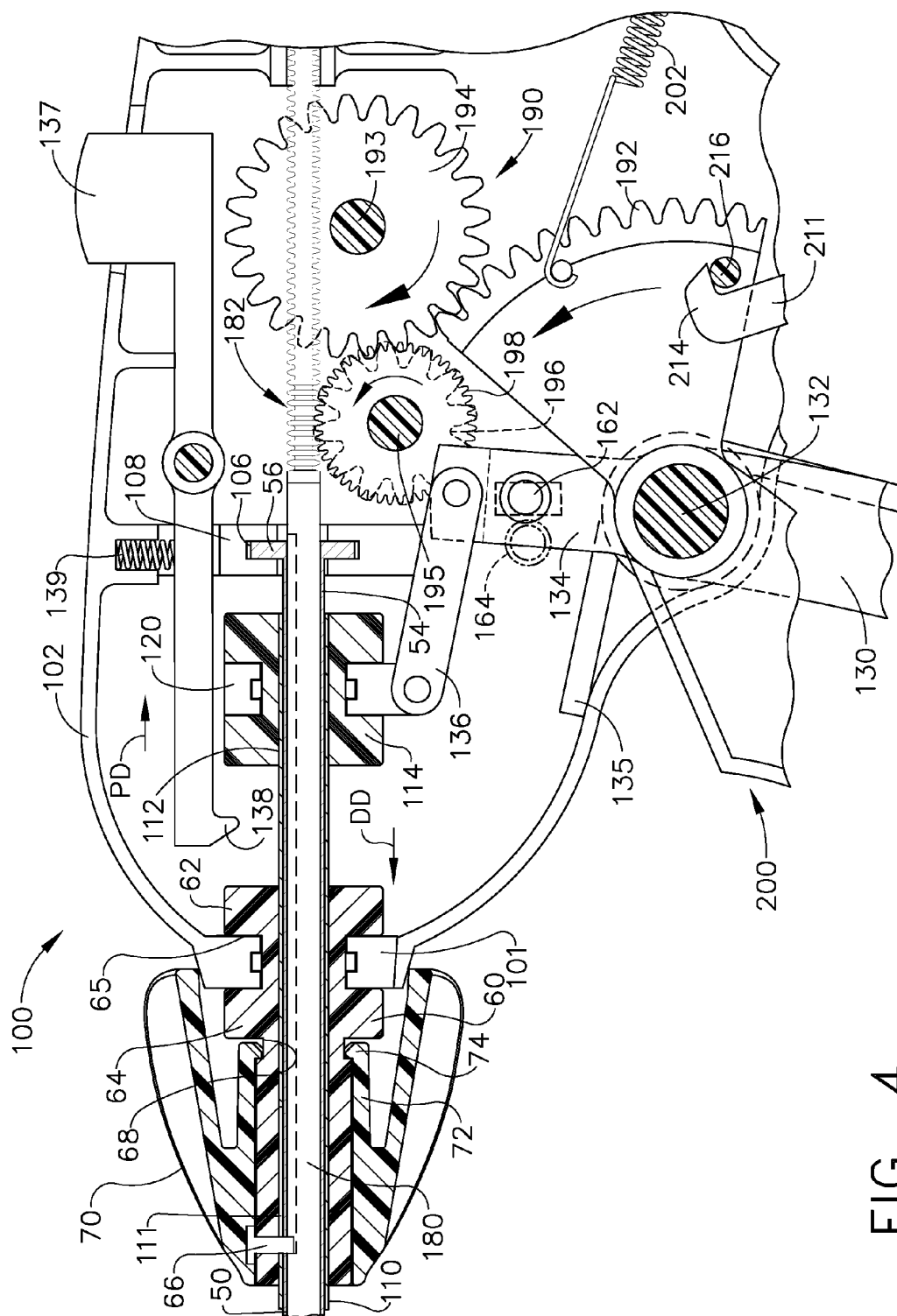
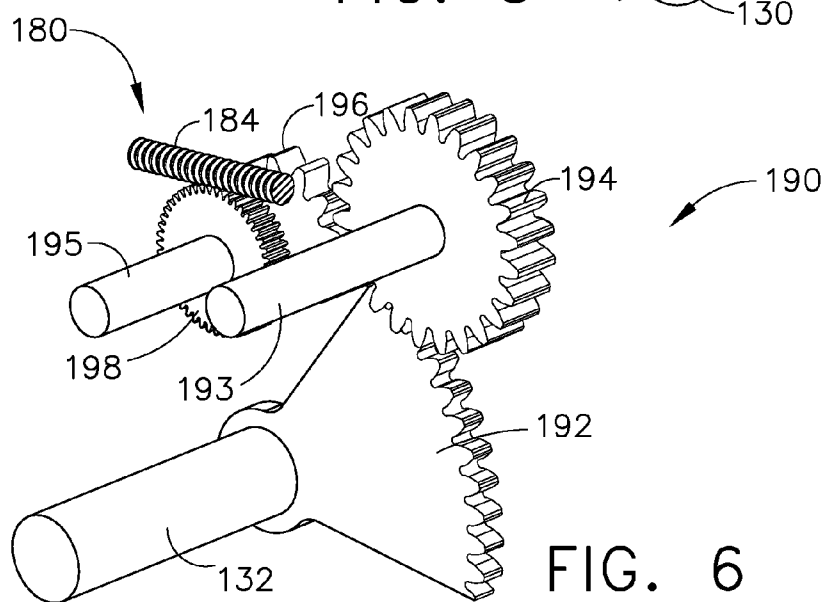
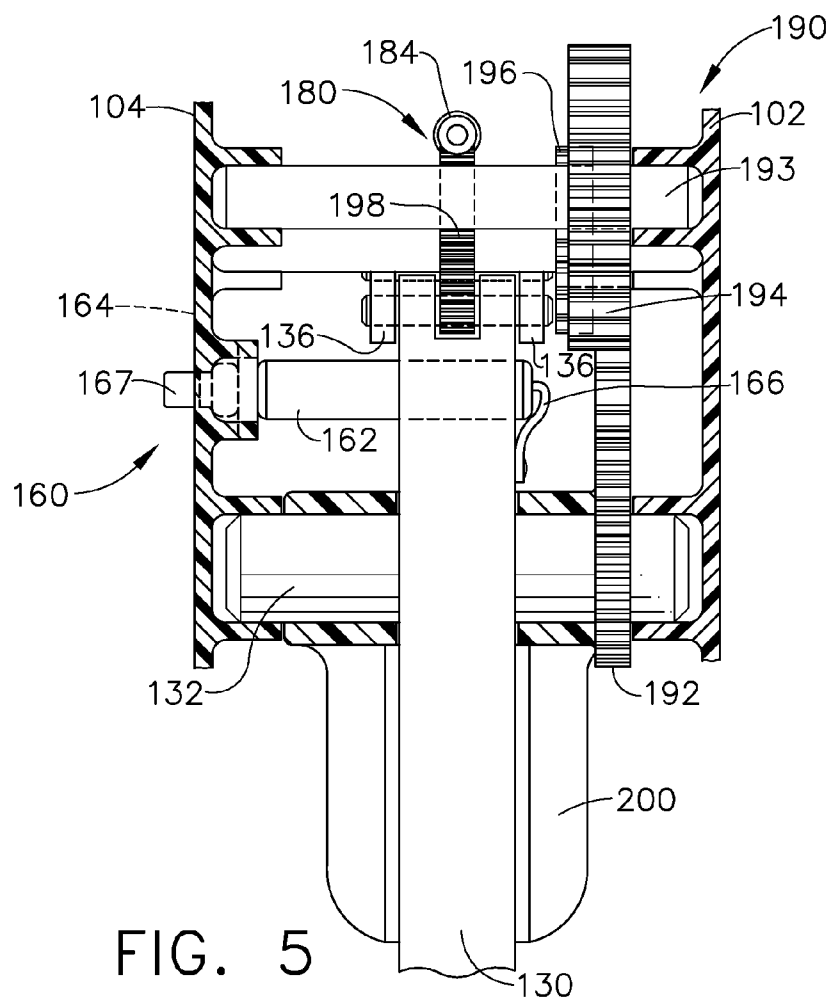
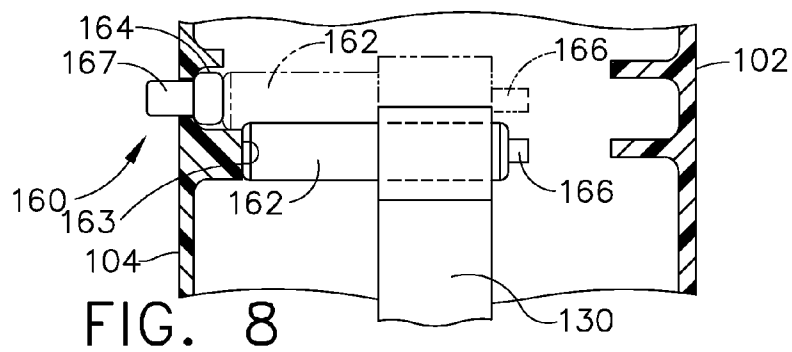
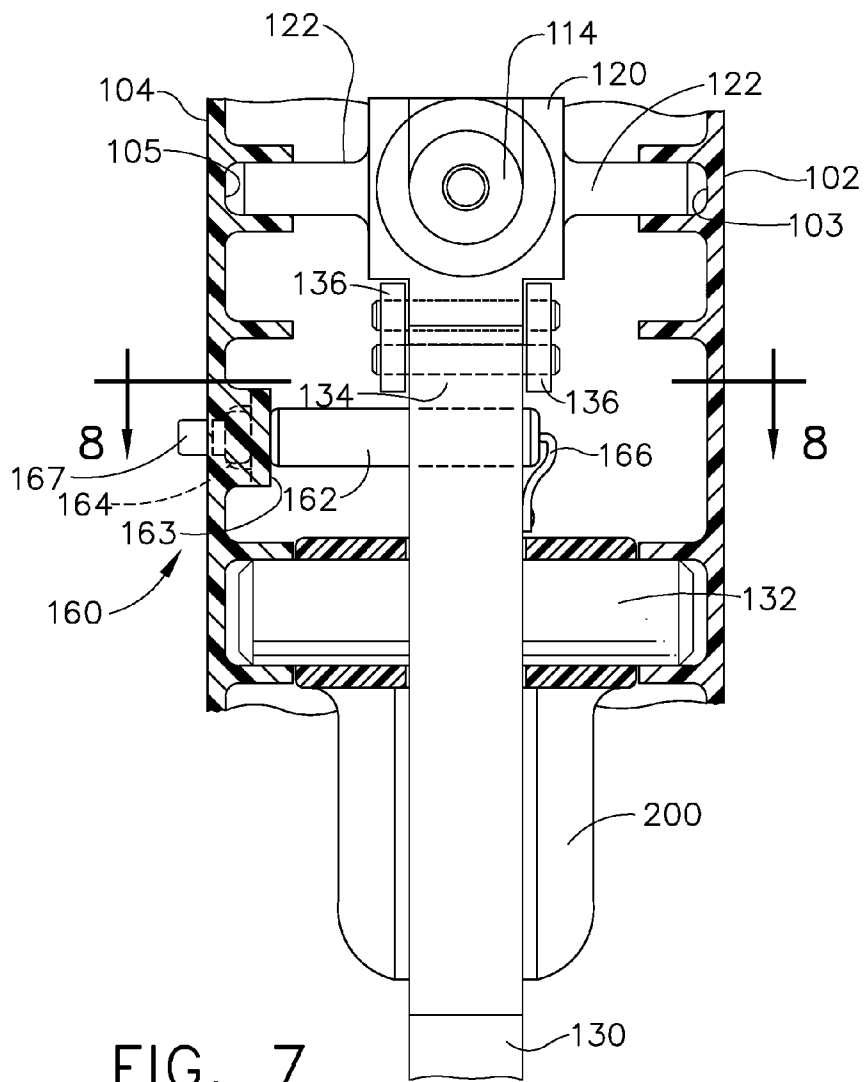


FIG. 4





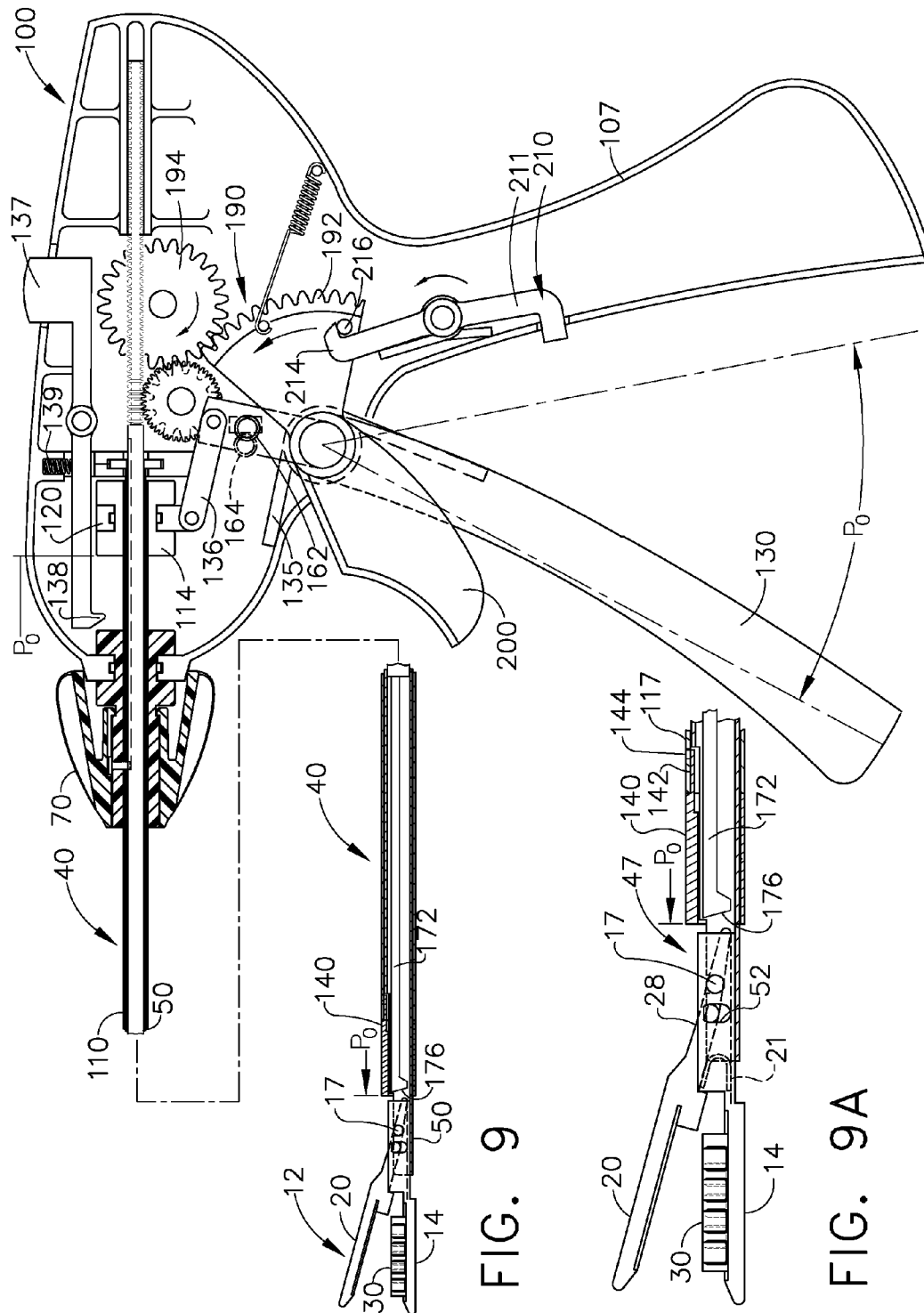


Fig. 9

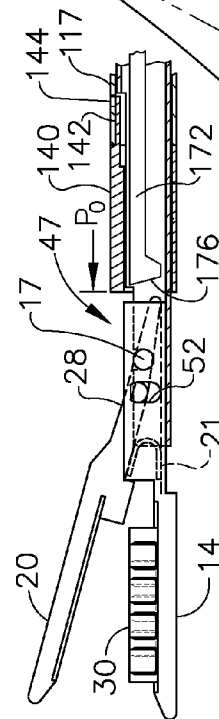


FIG. 9A

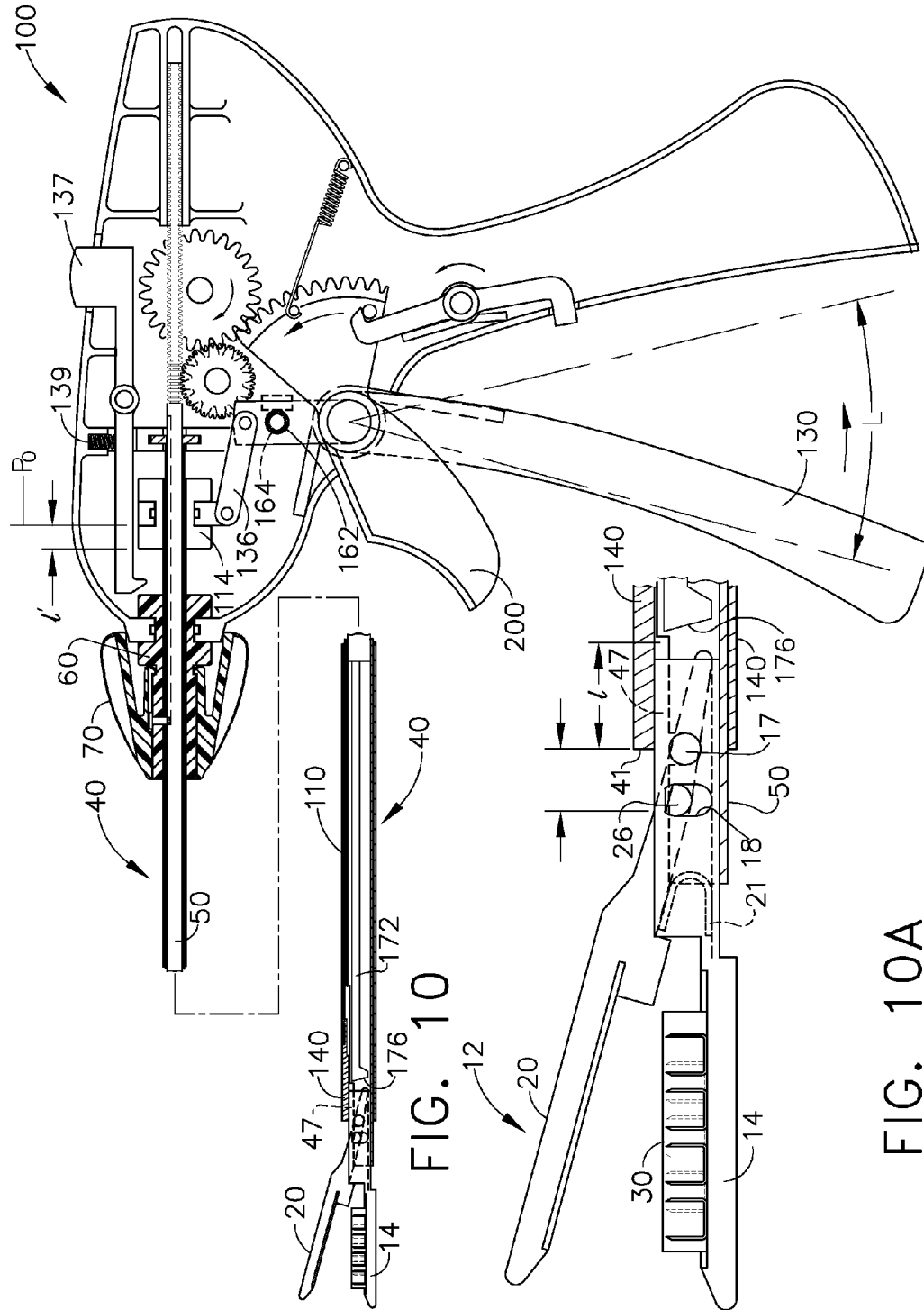


FIG. 10A

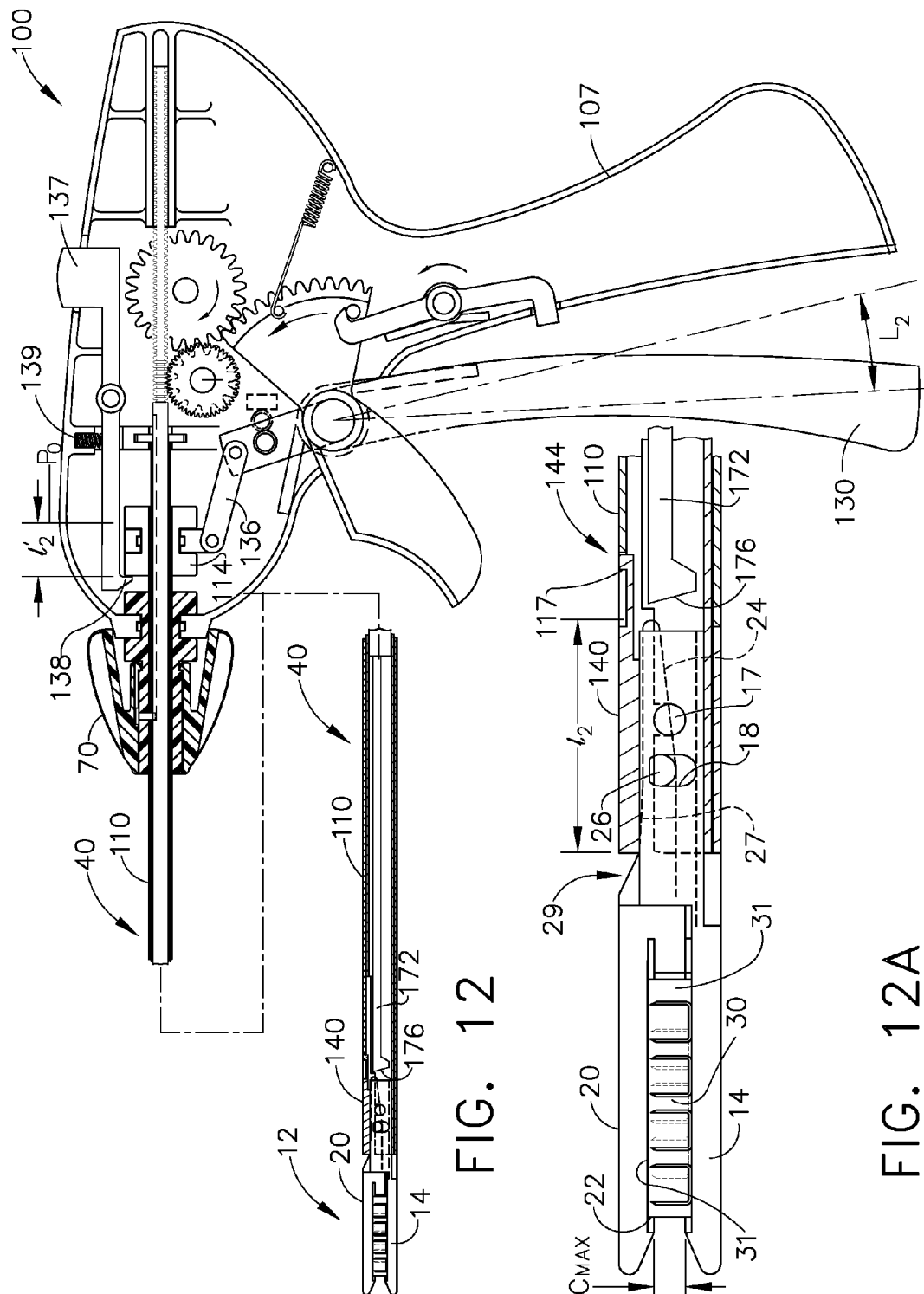


FIG. 12A

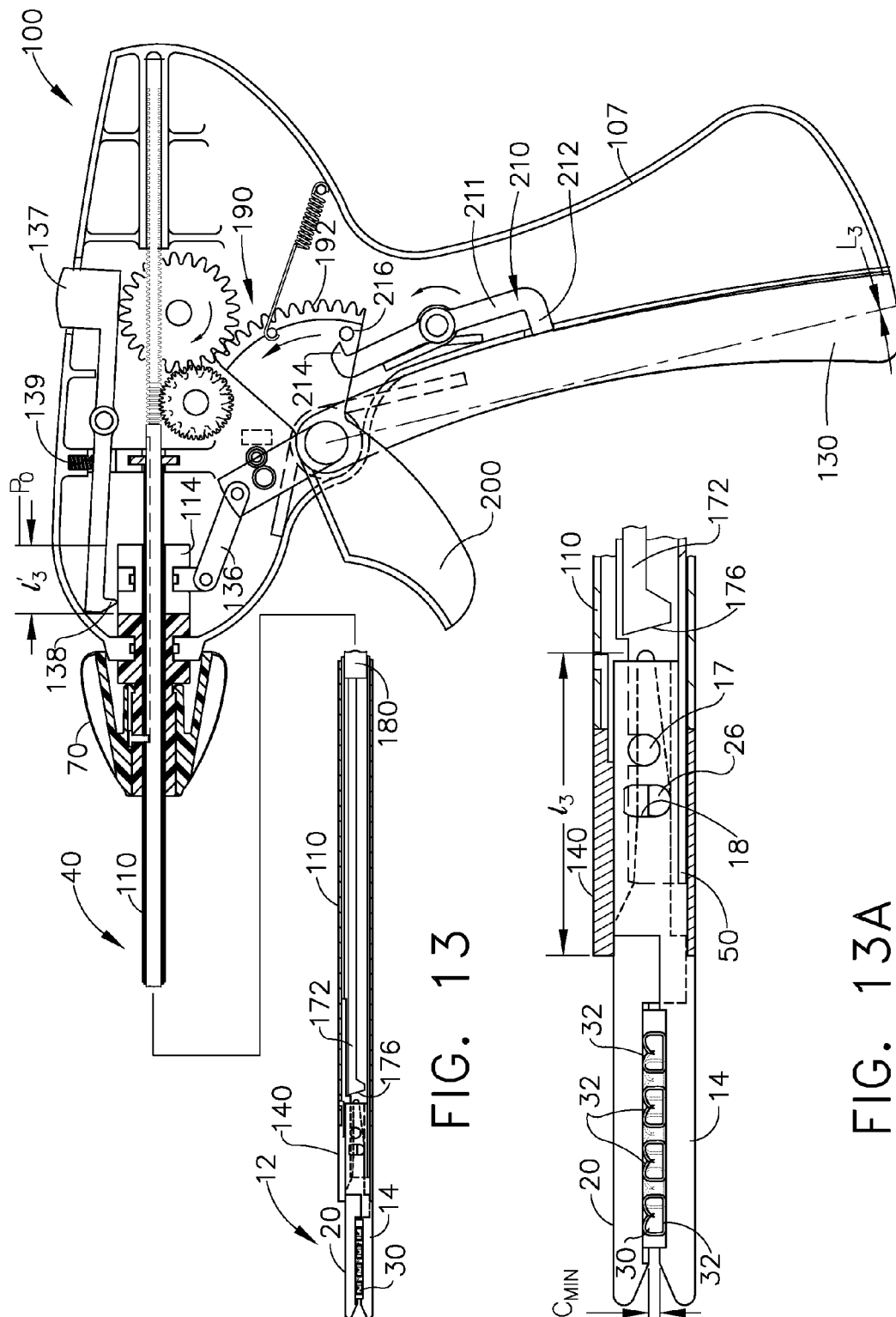


FIG. 13A

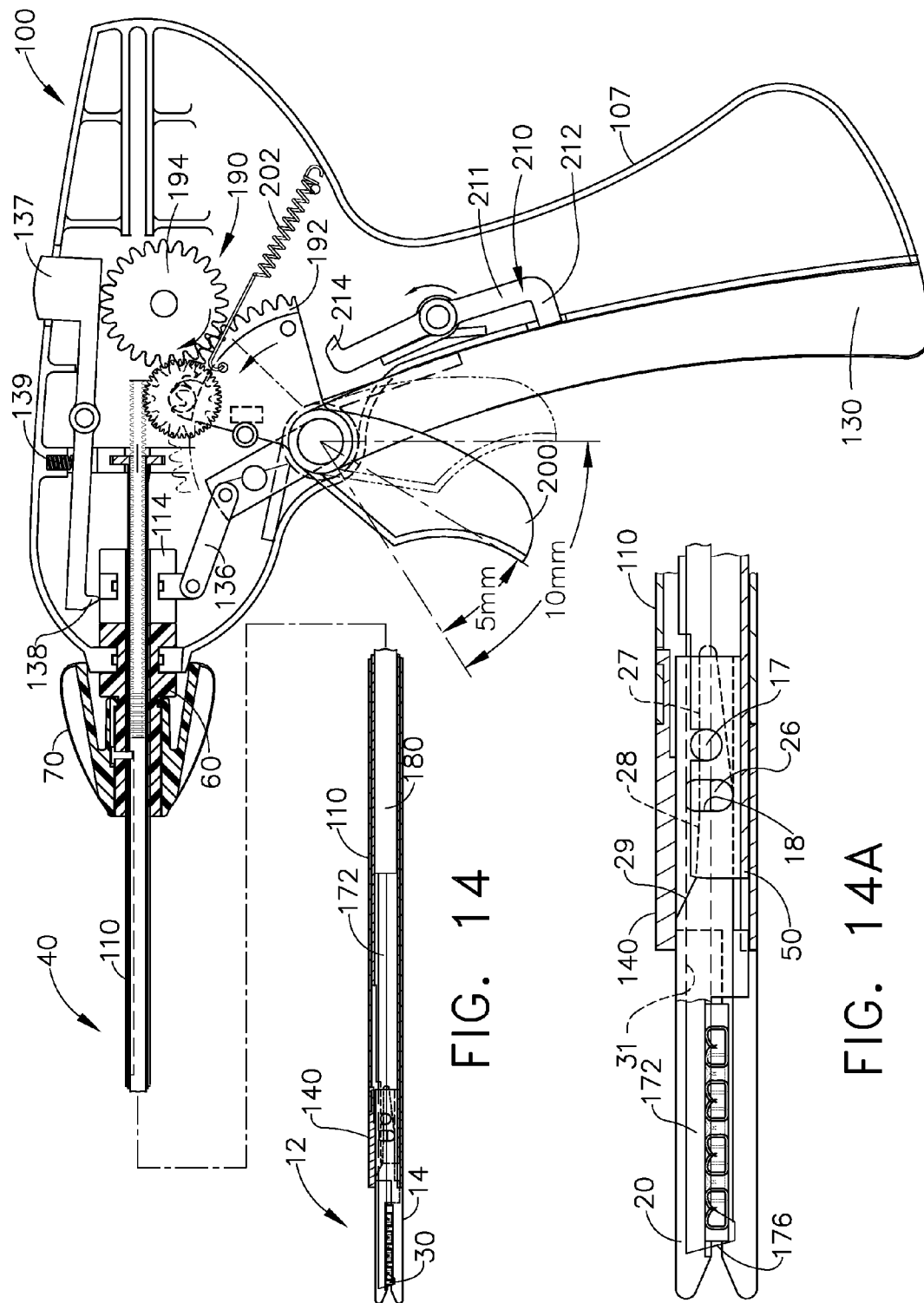
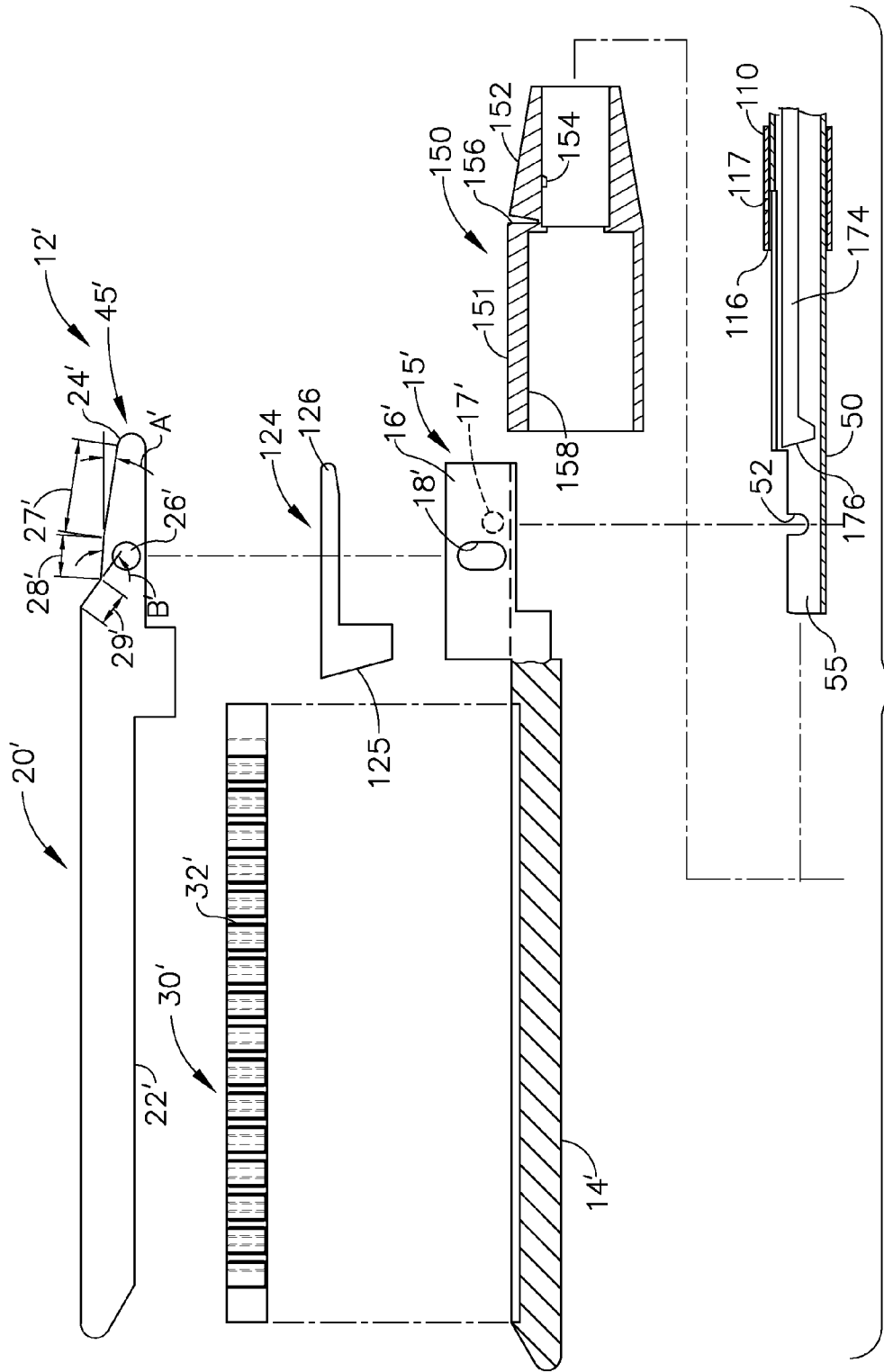


FIG. 14

FIG. 14A



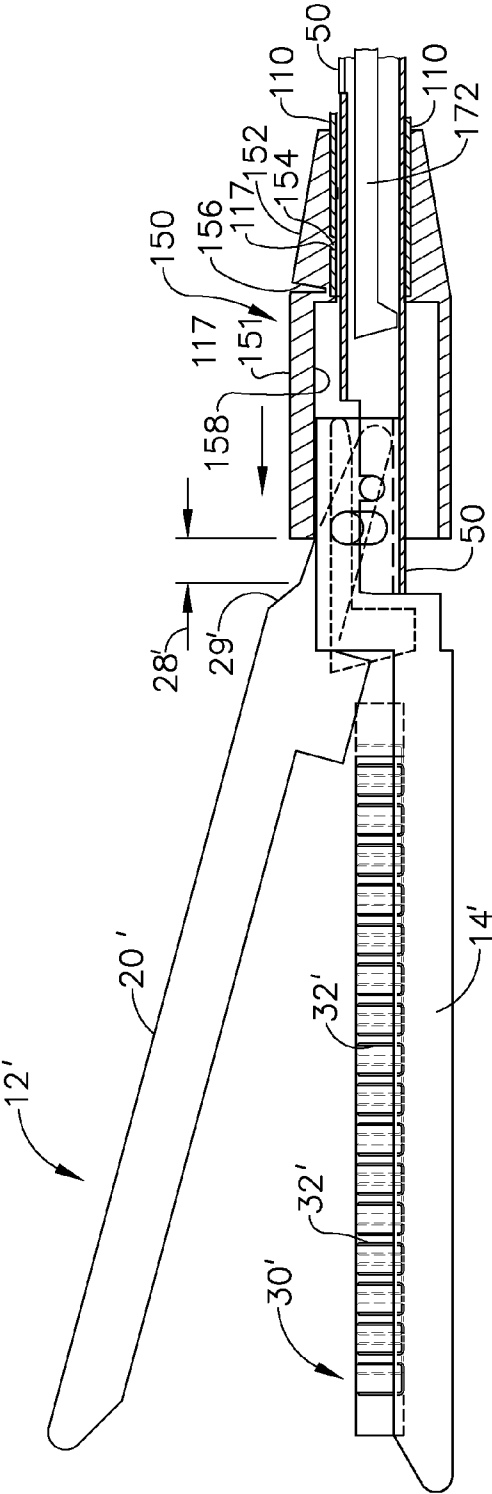


FIG. 16

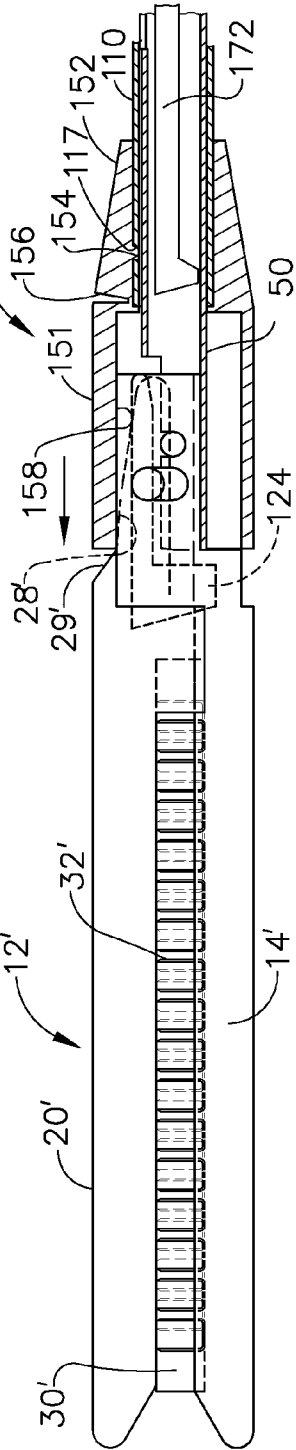


FIG. 17

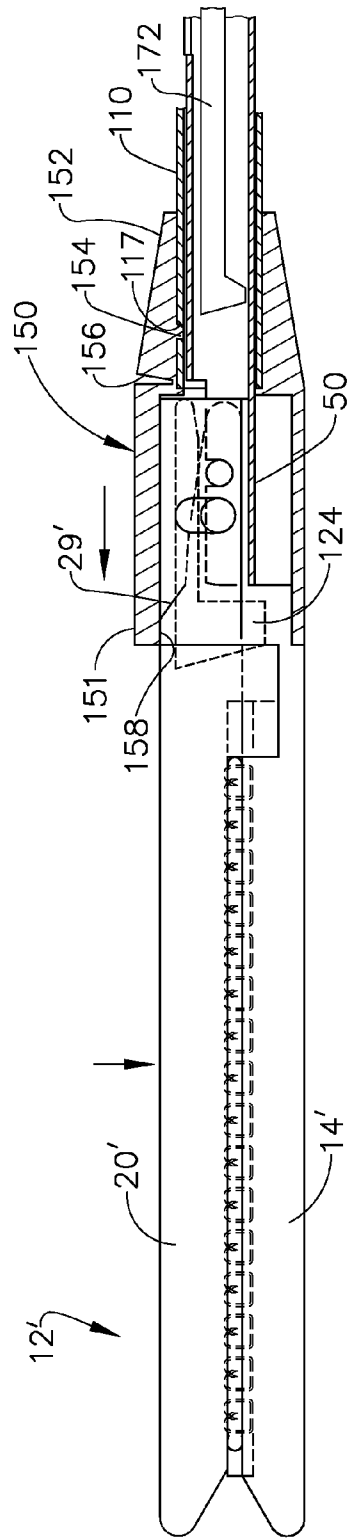


FIG. 18

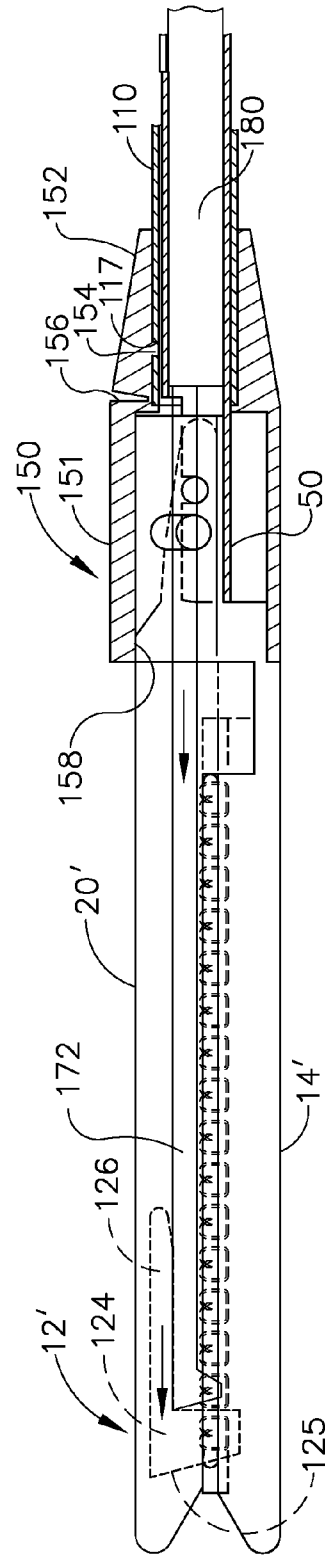


FIG. 19

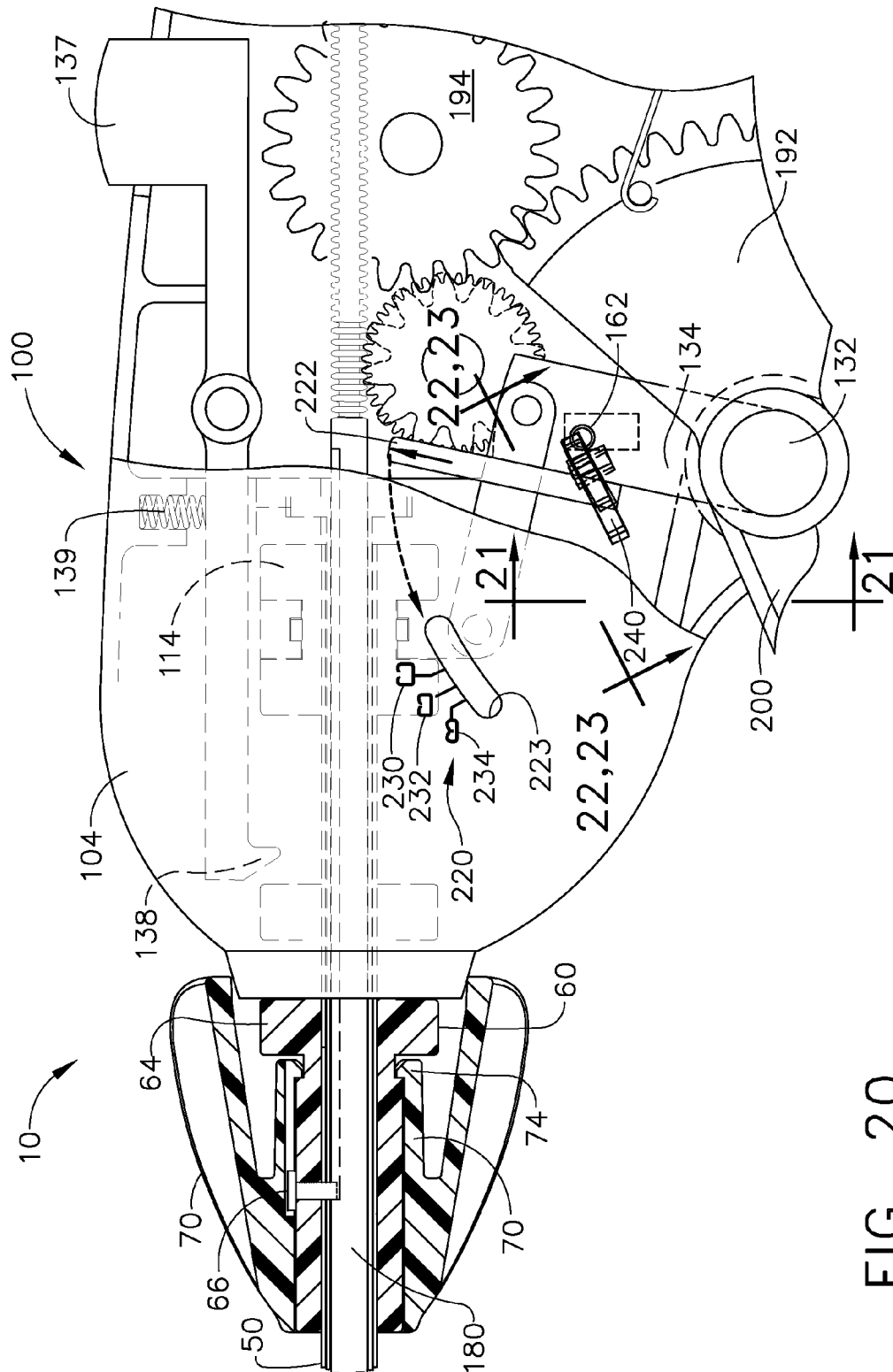


FIG. 20

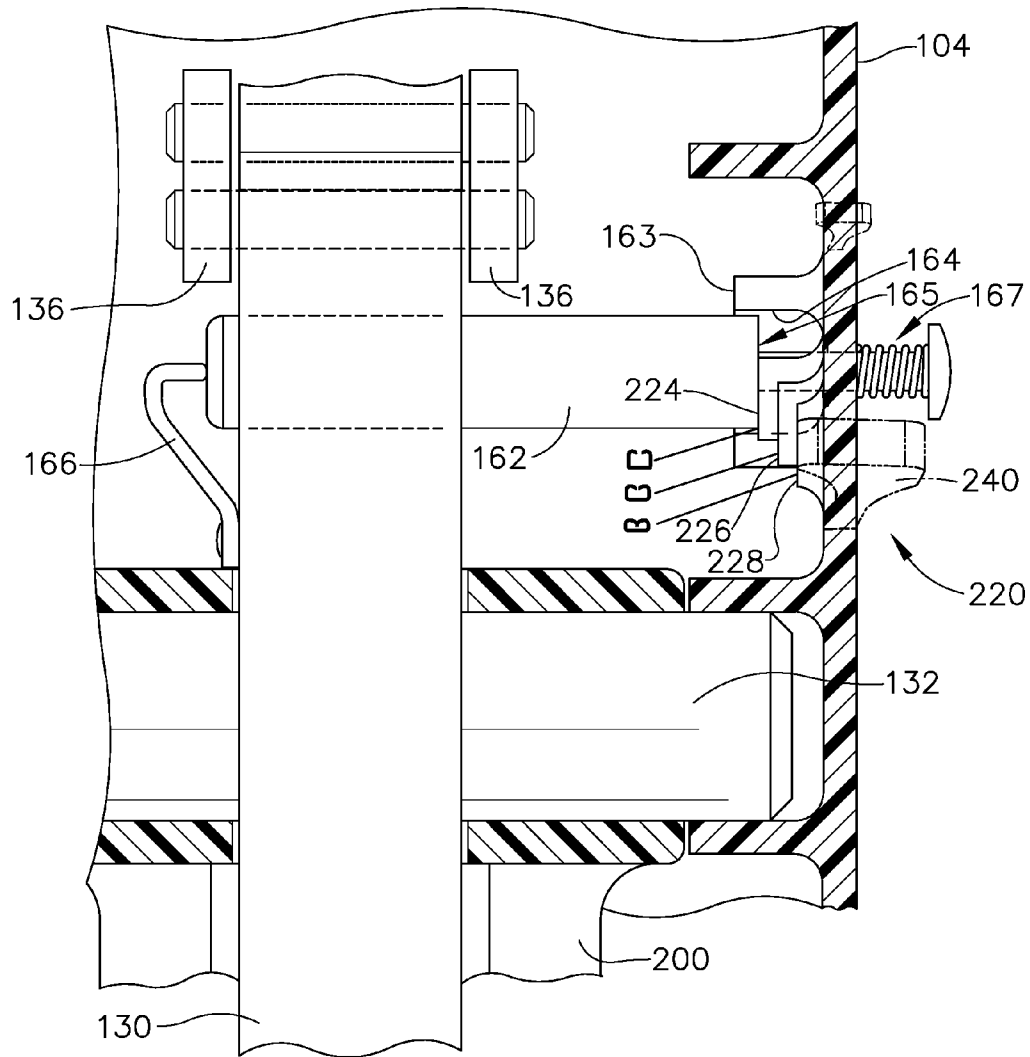


FIG. 21

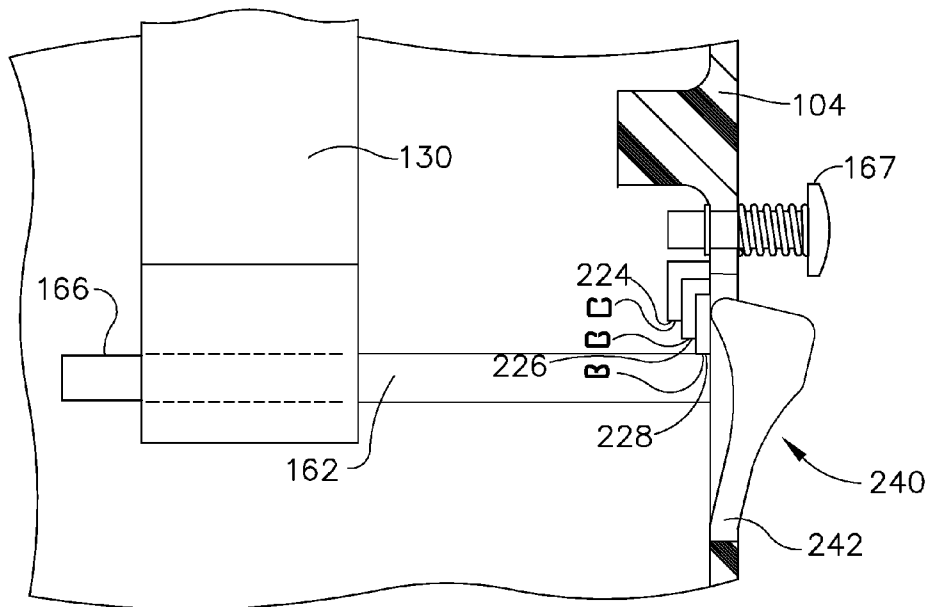


FIG. 22

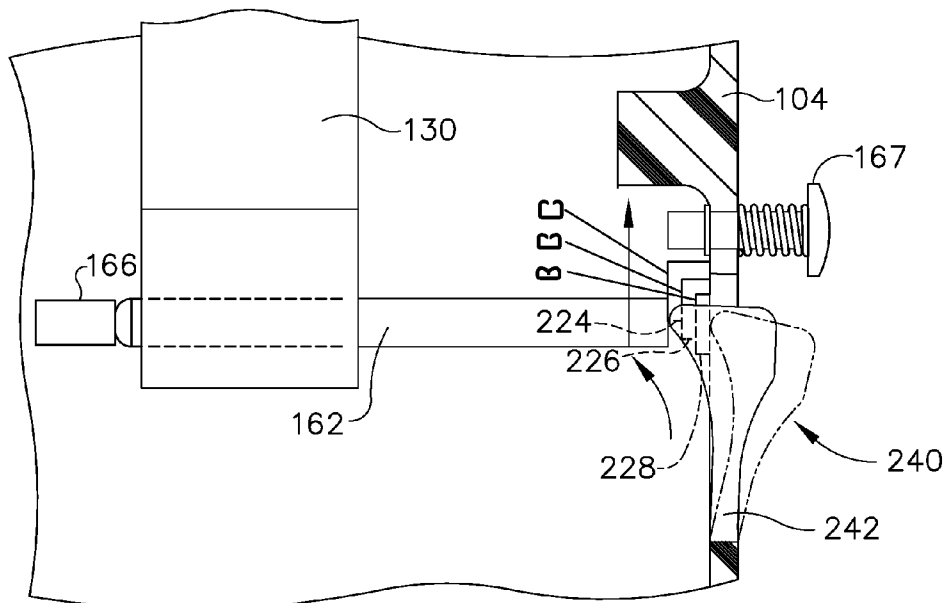


FIG. 23

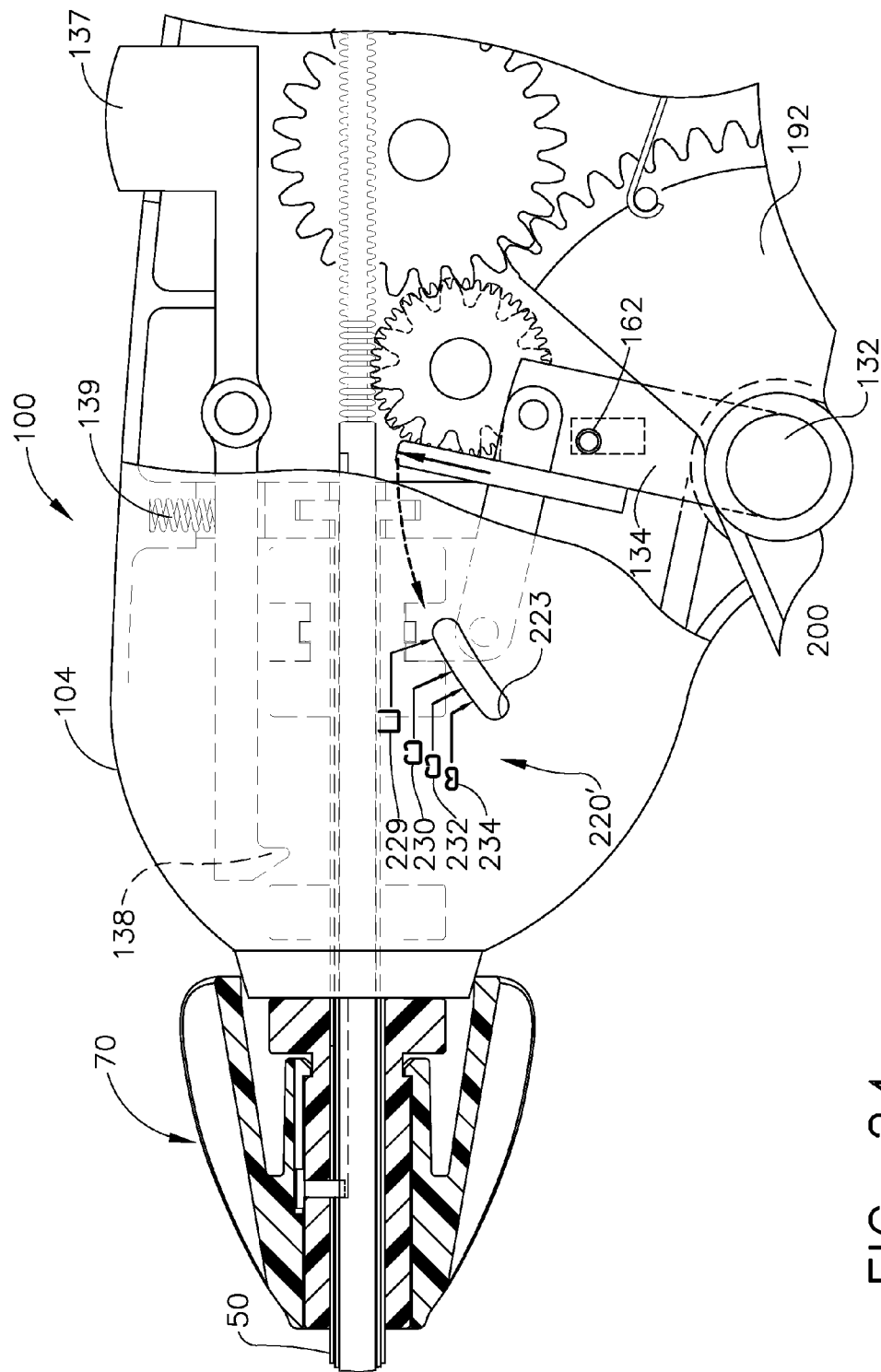
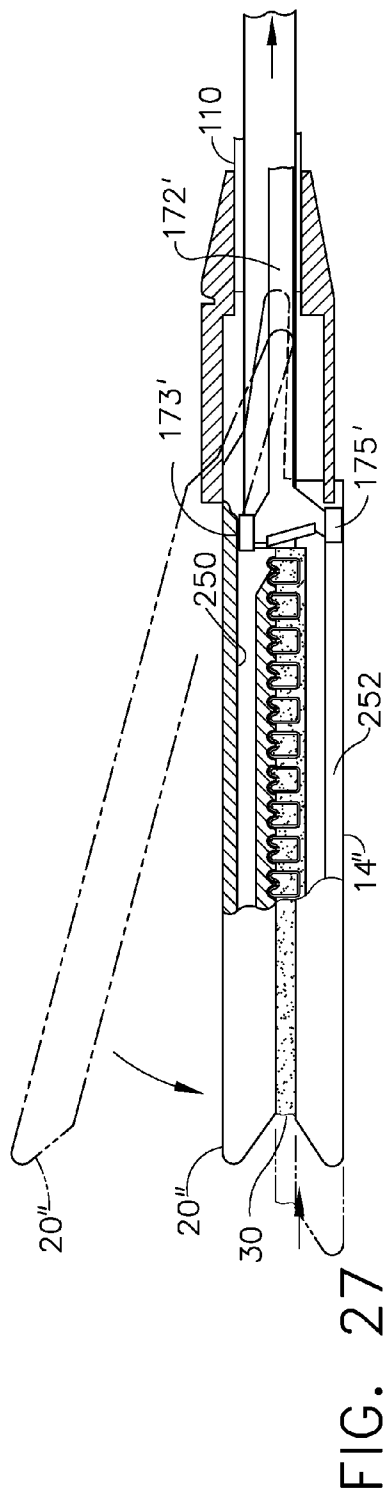
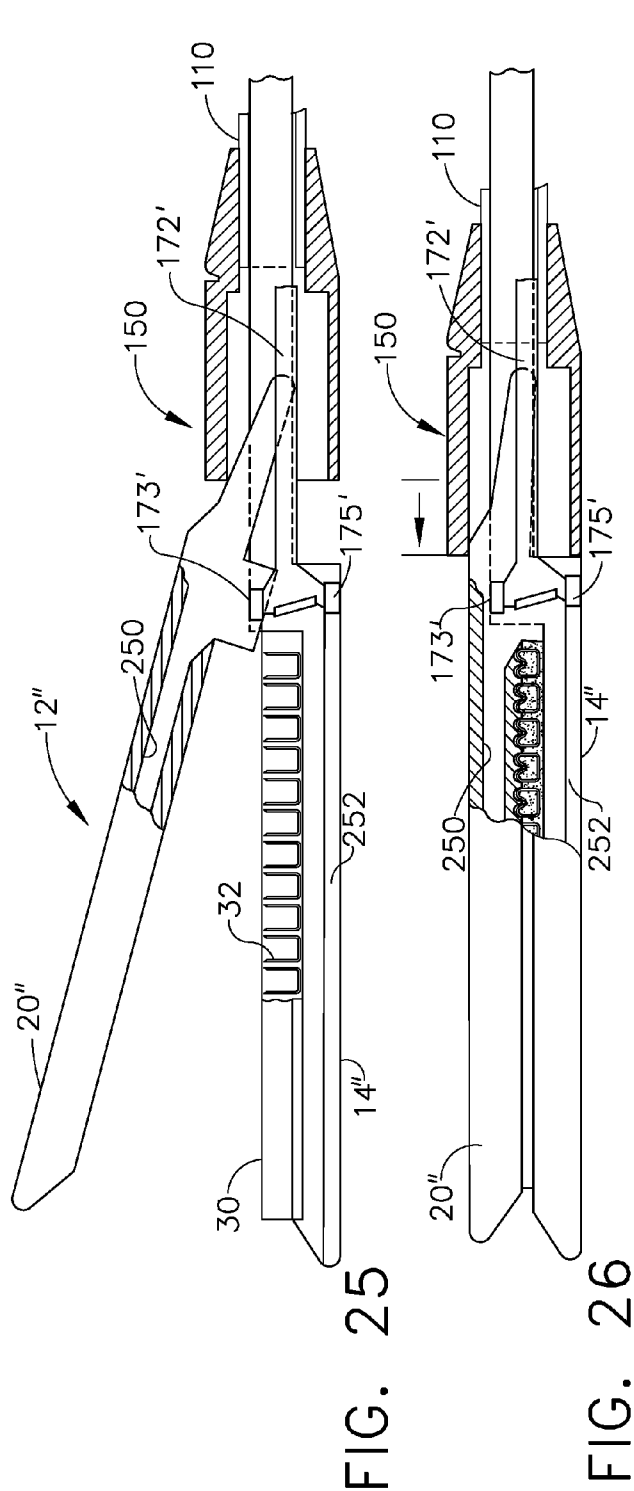
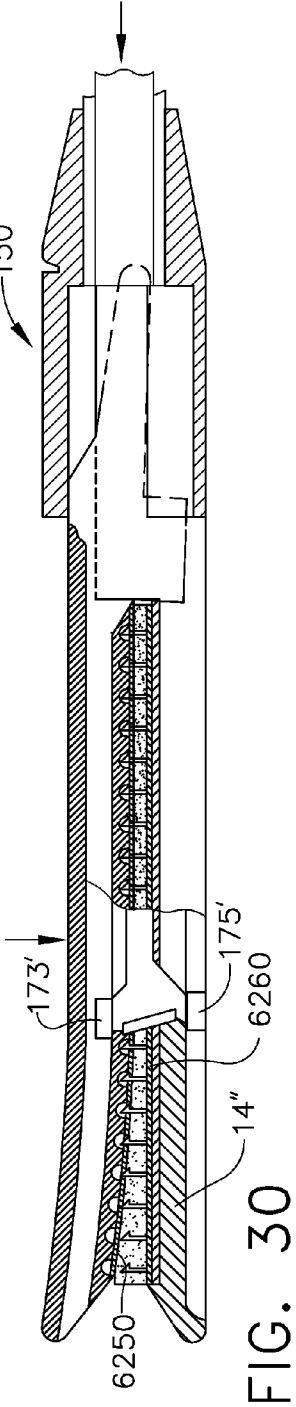
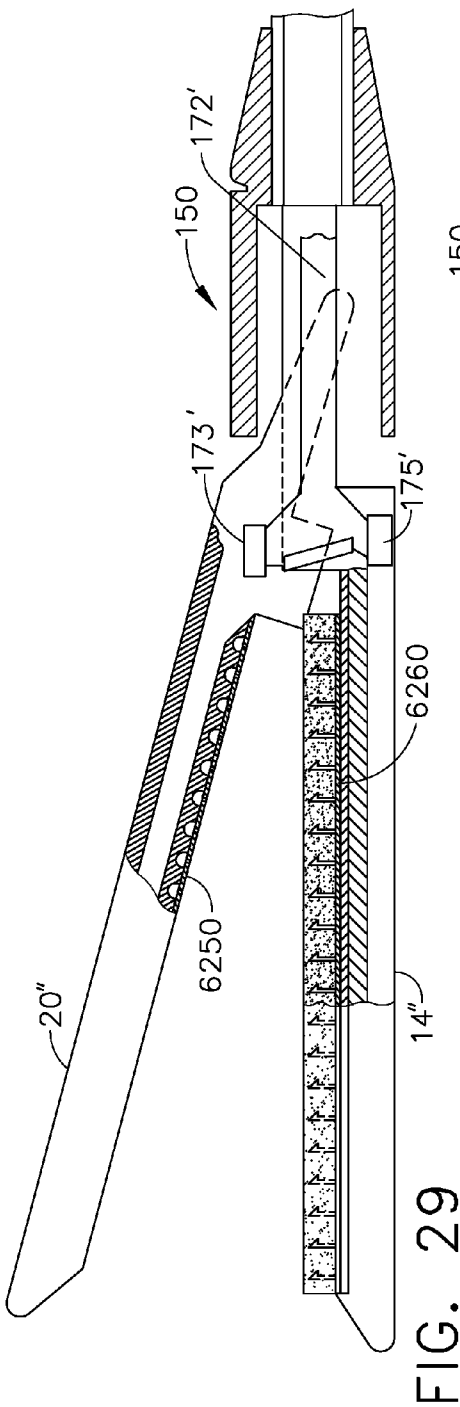
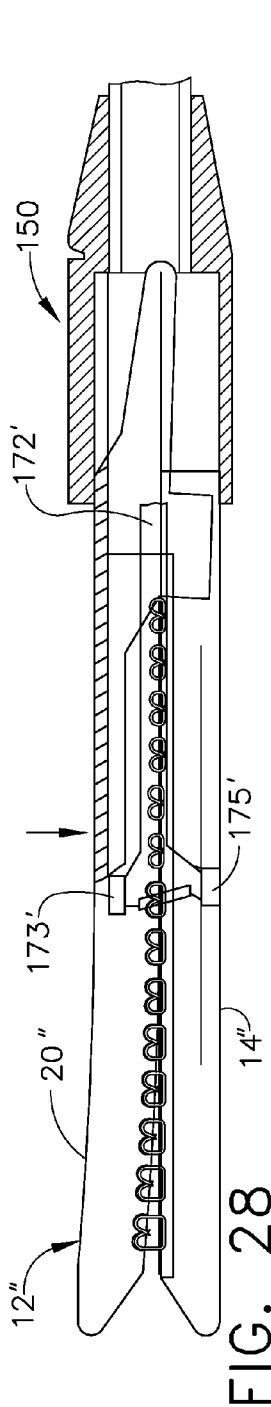


FIG. 24





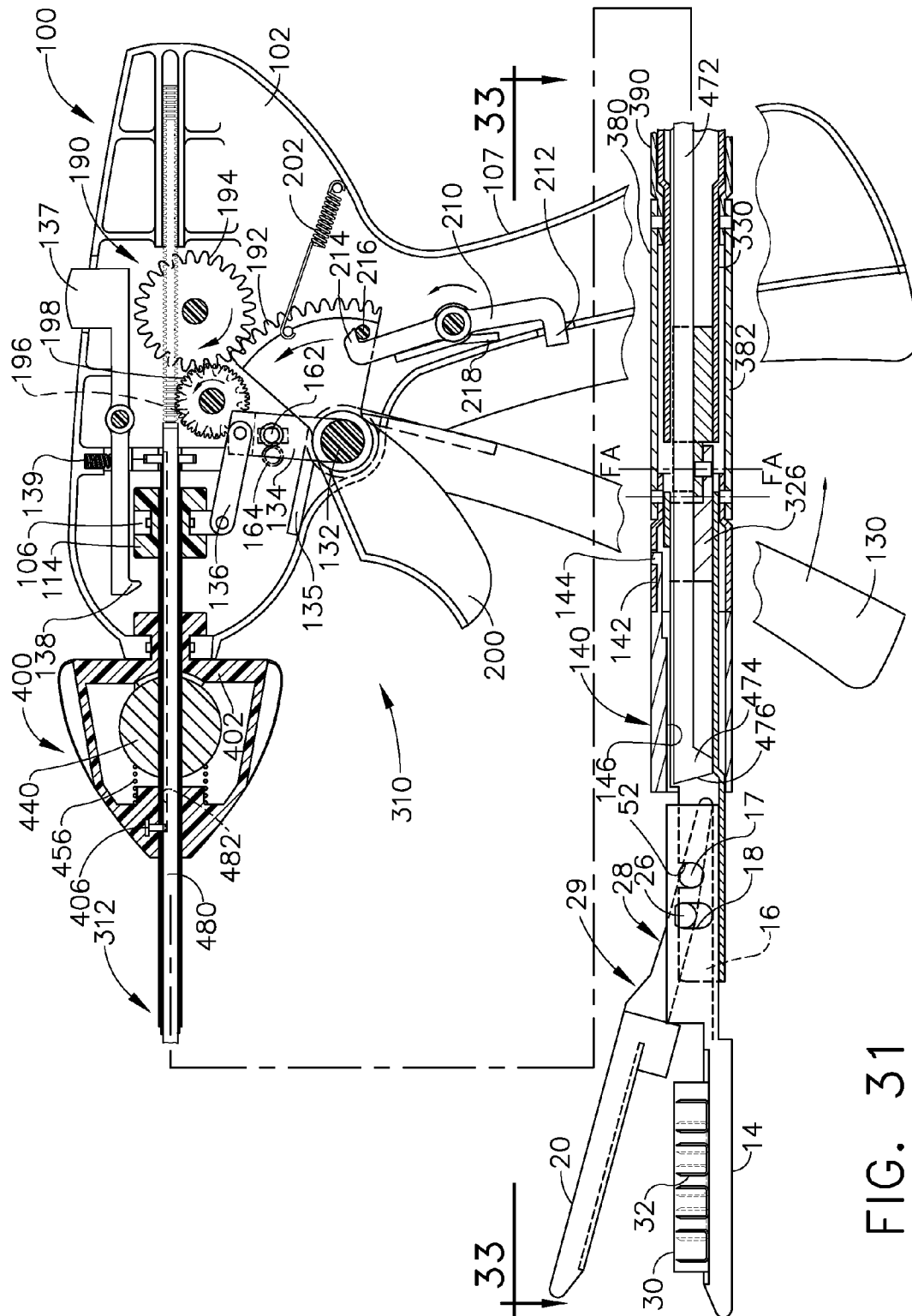


FIG. 31

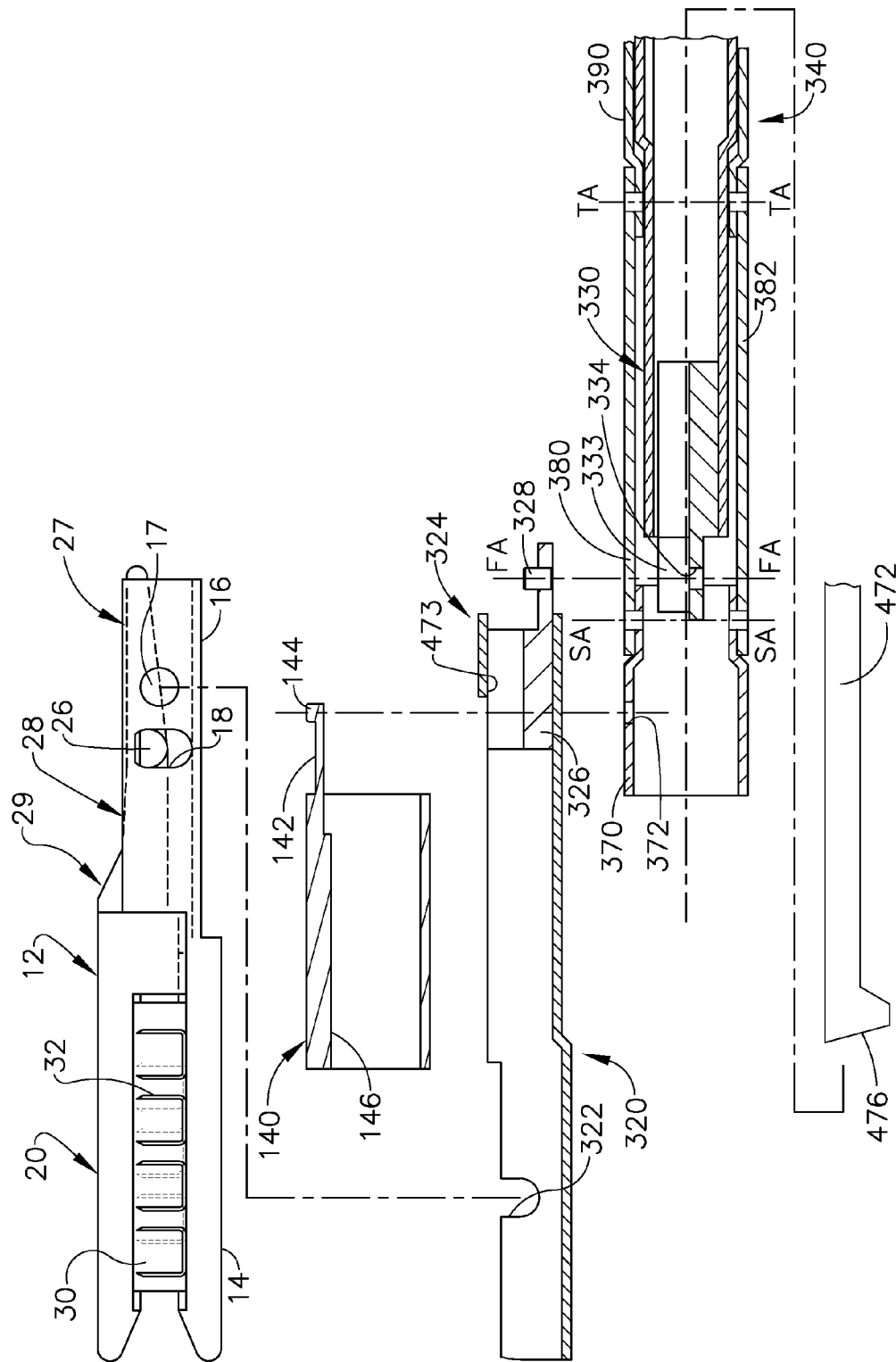


FIG. 32

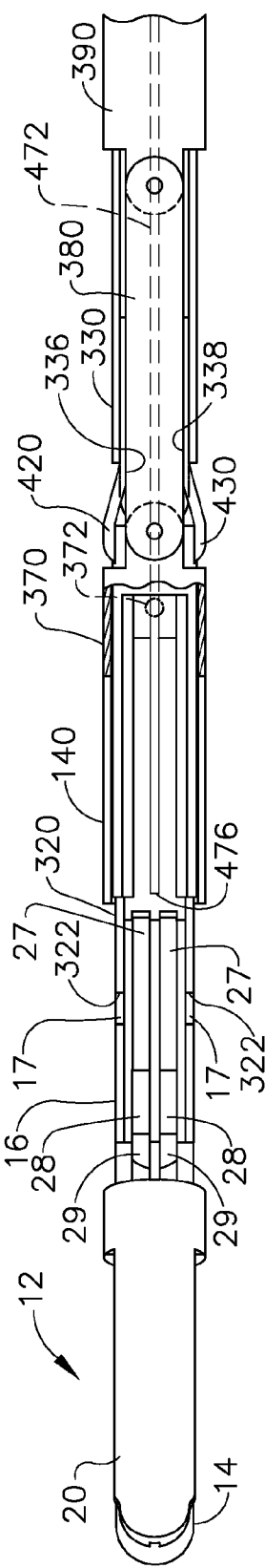


FIG. 33

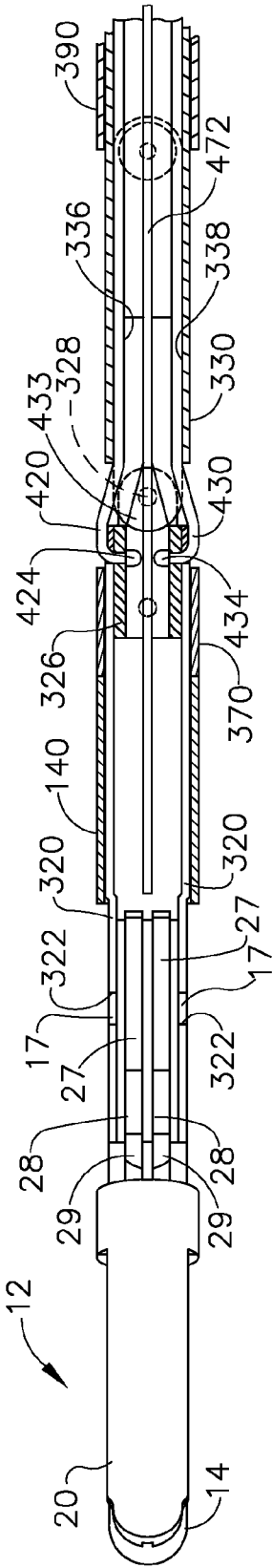
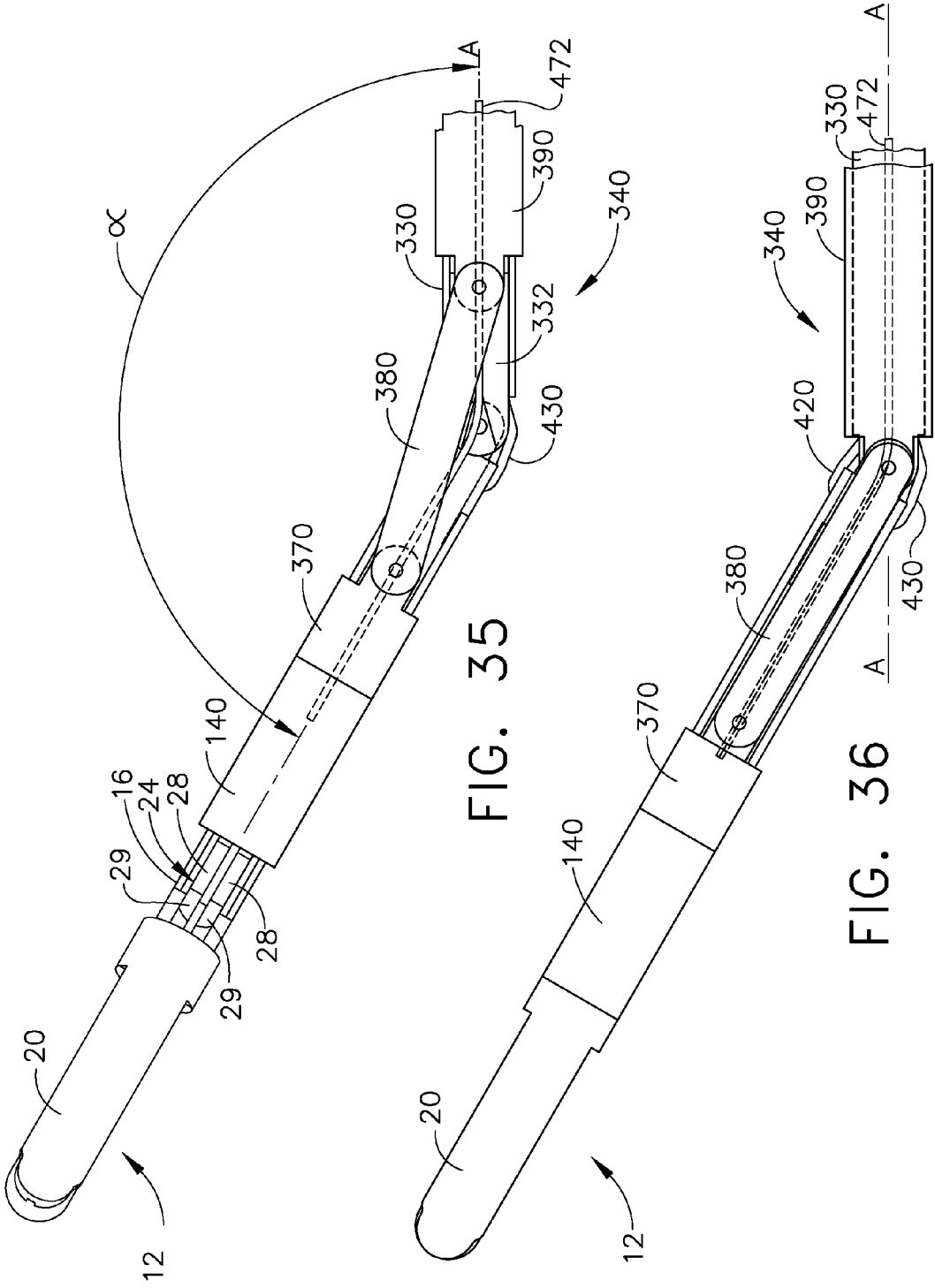


FIG. 34



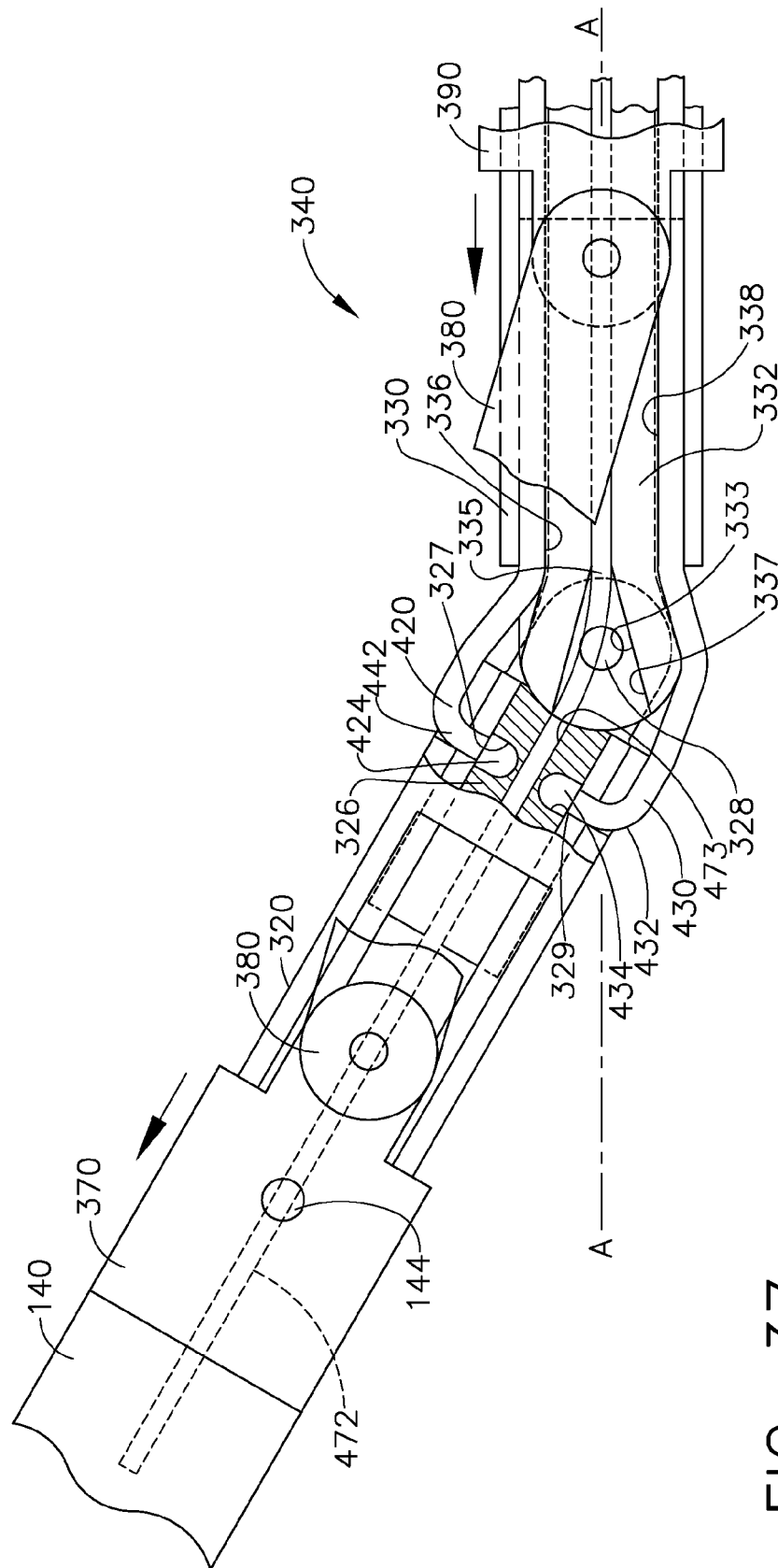


FIG. 37

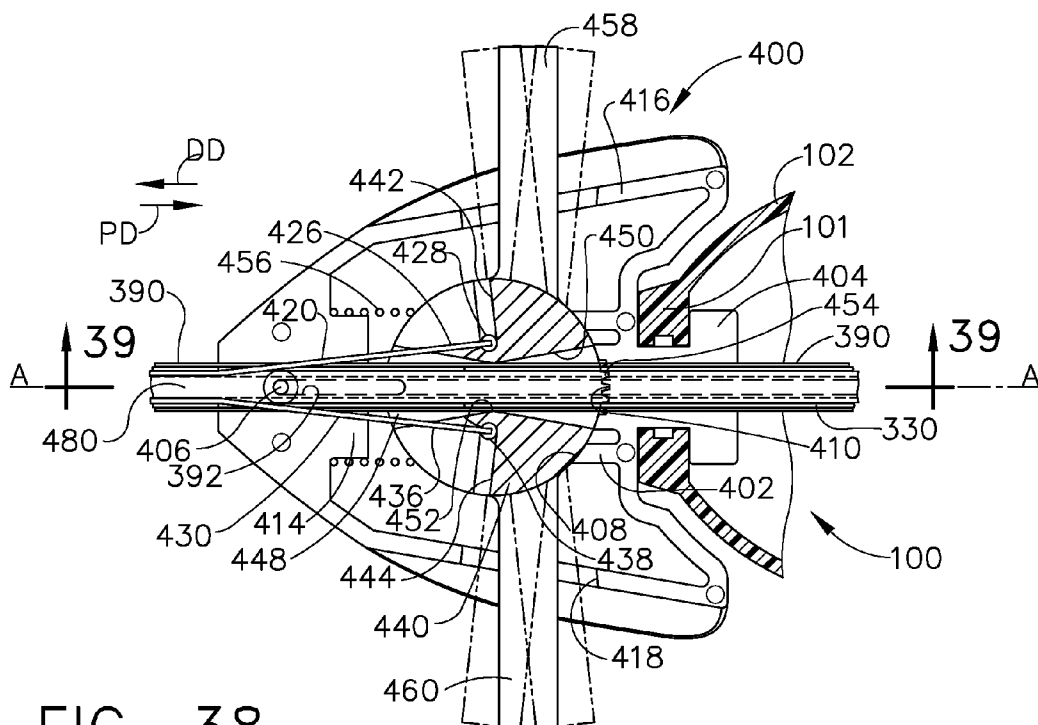


FIG. 38

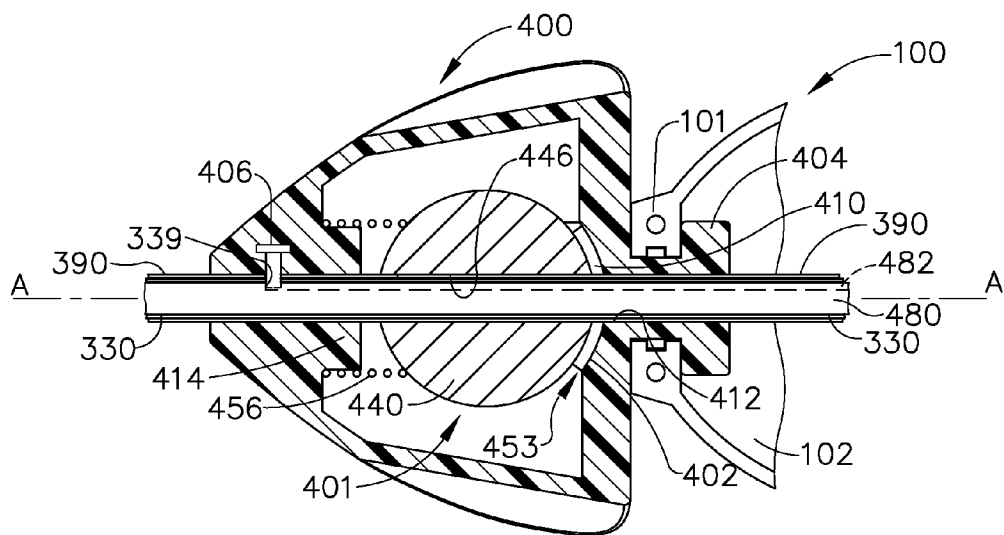


FIG. 39

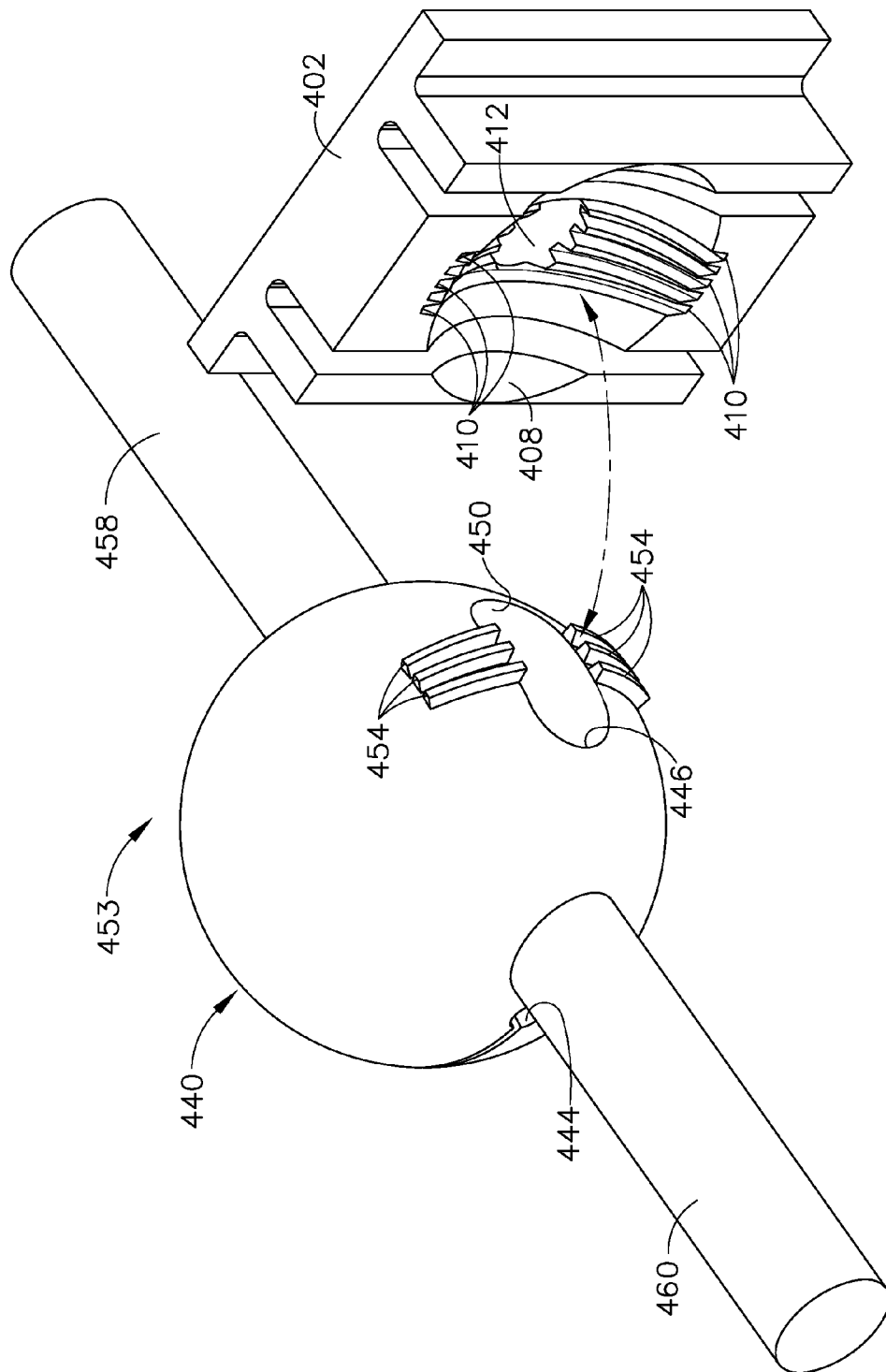
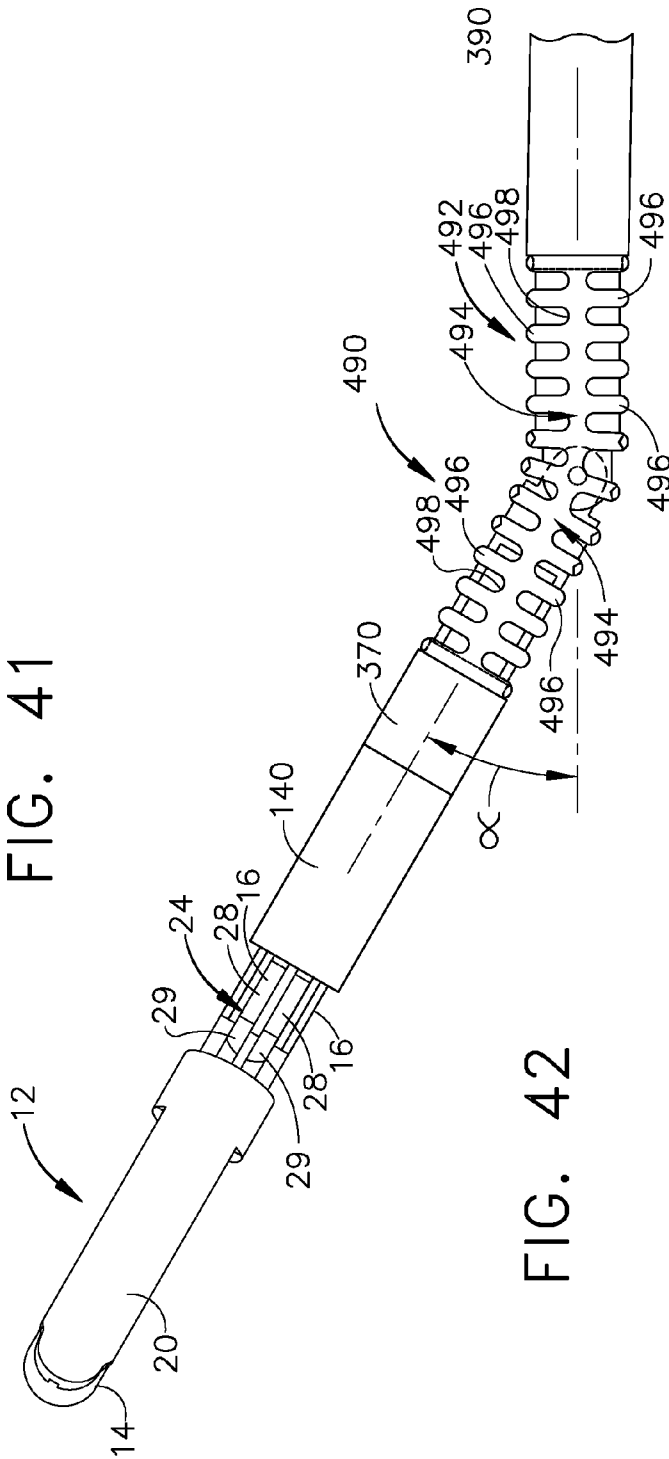
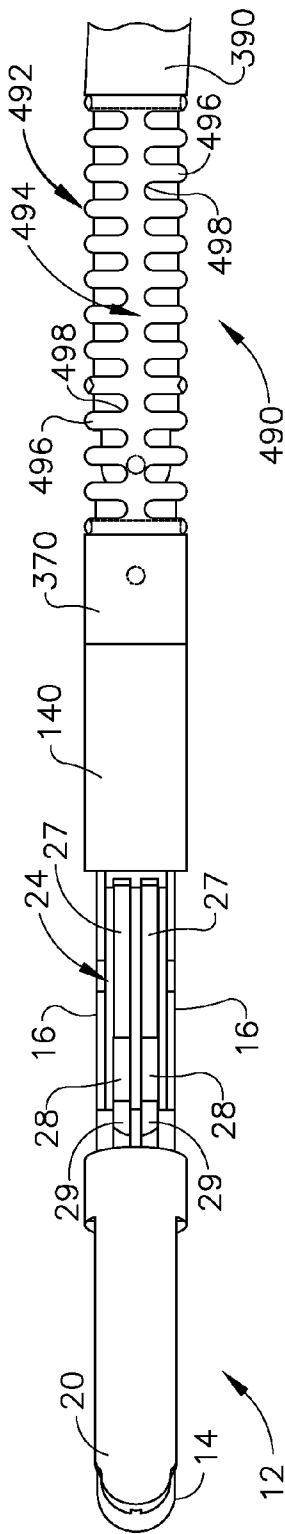


FIG. 40



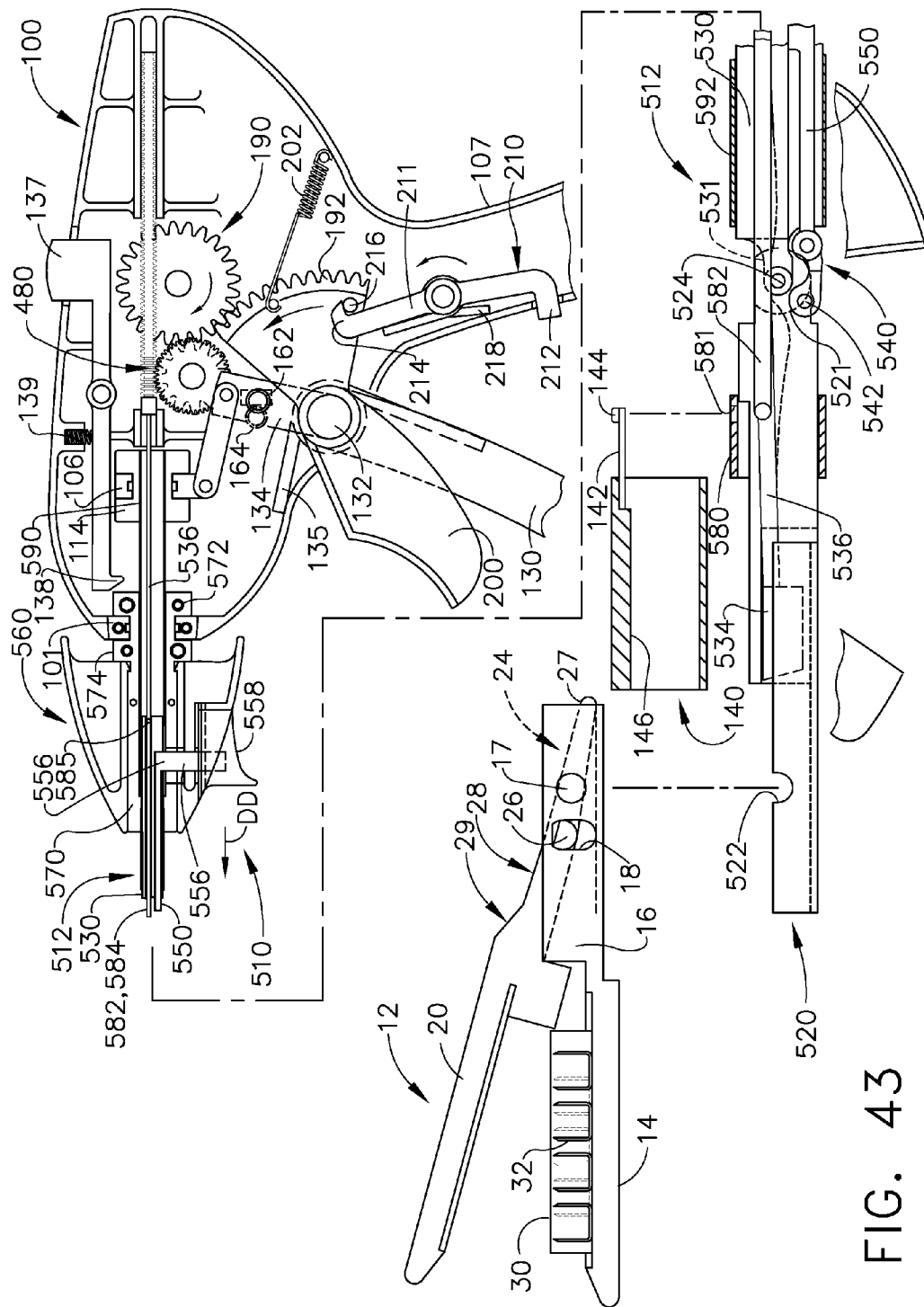


FIG. 43

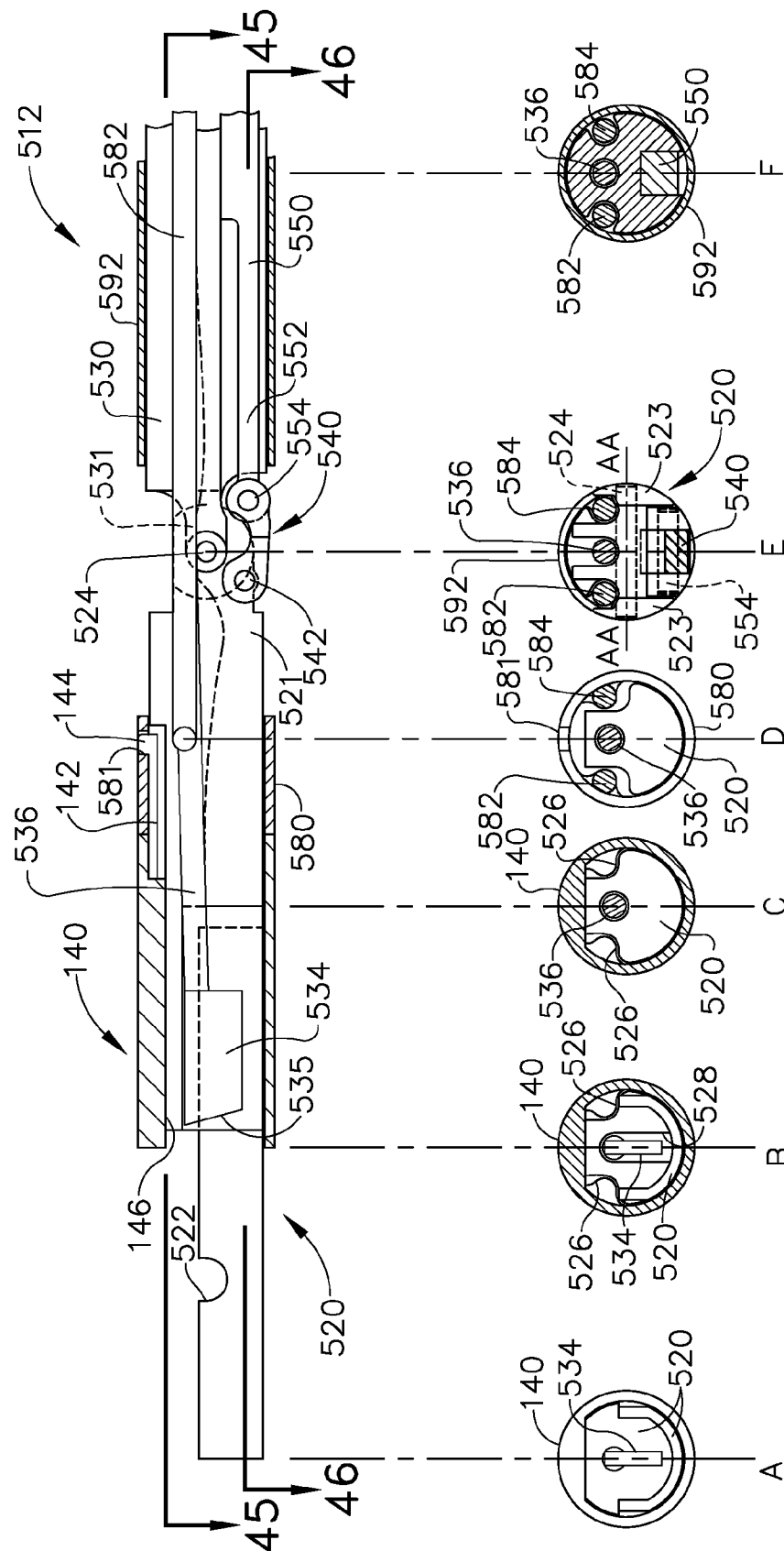


FIG. 44

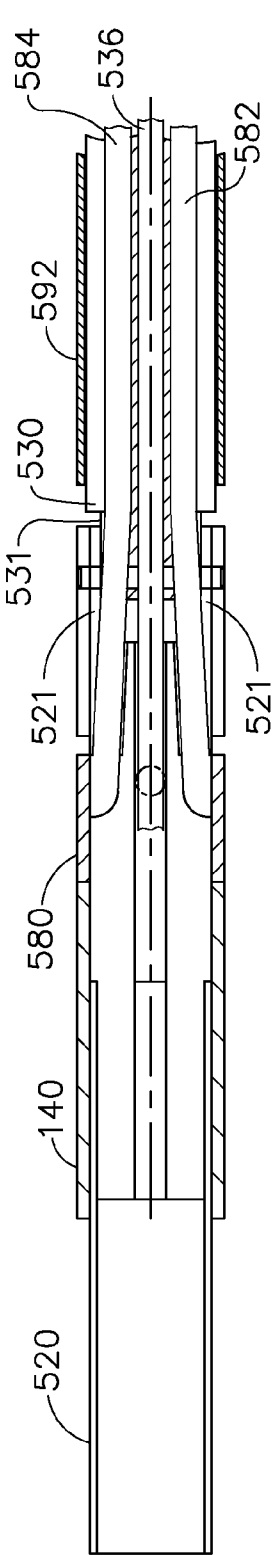


FIG. 45

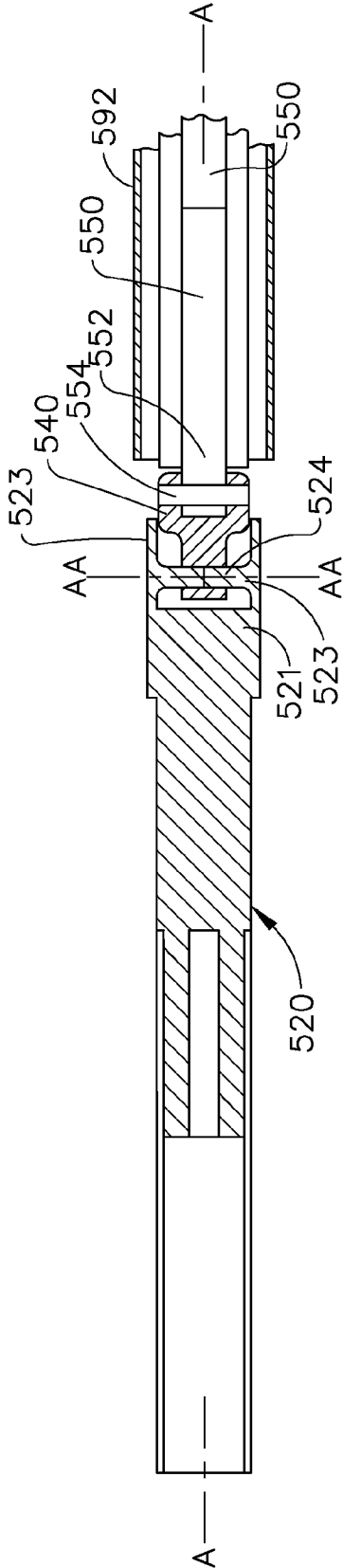


FIG. 46

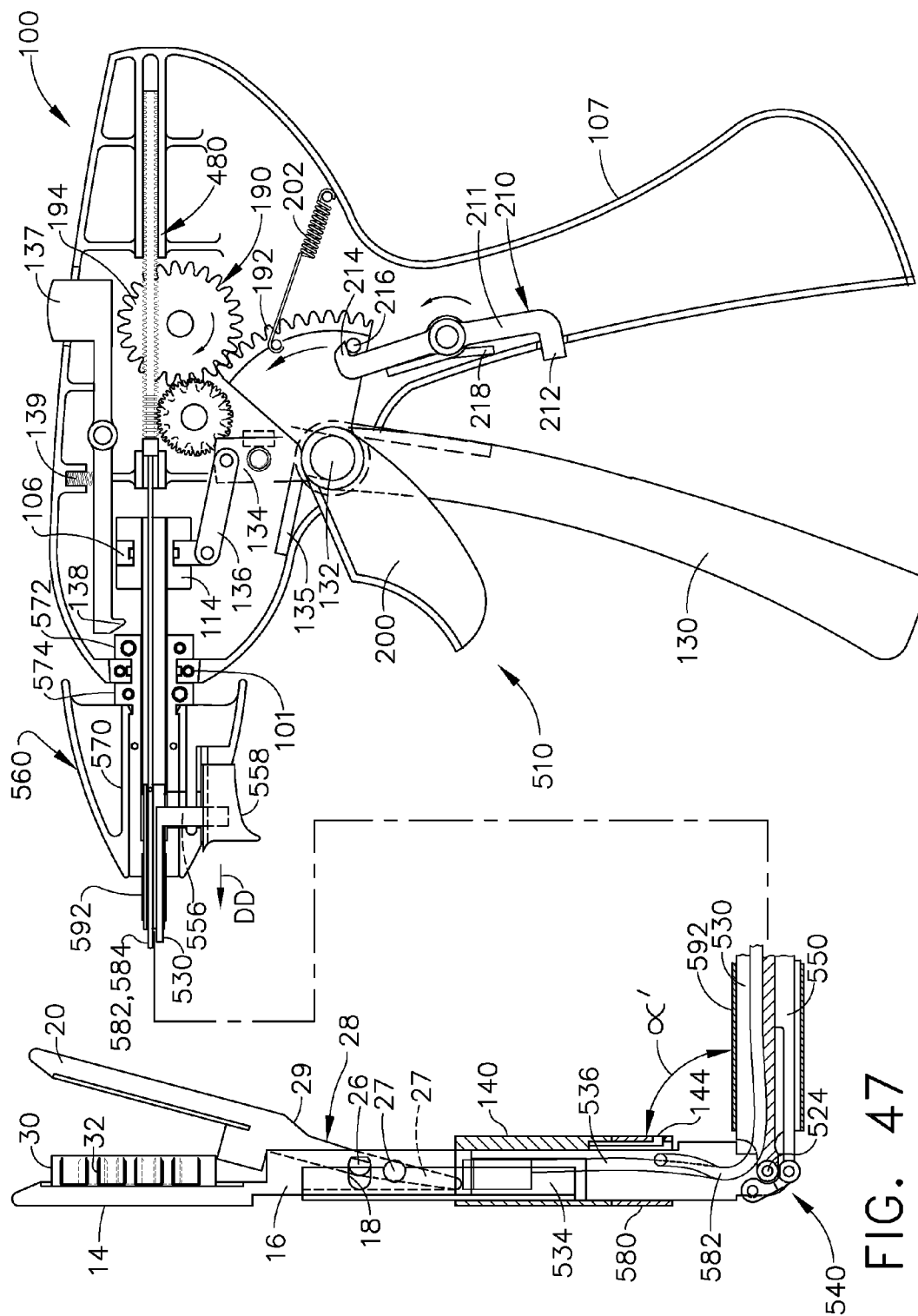


FIG. 47

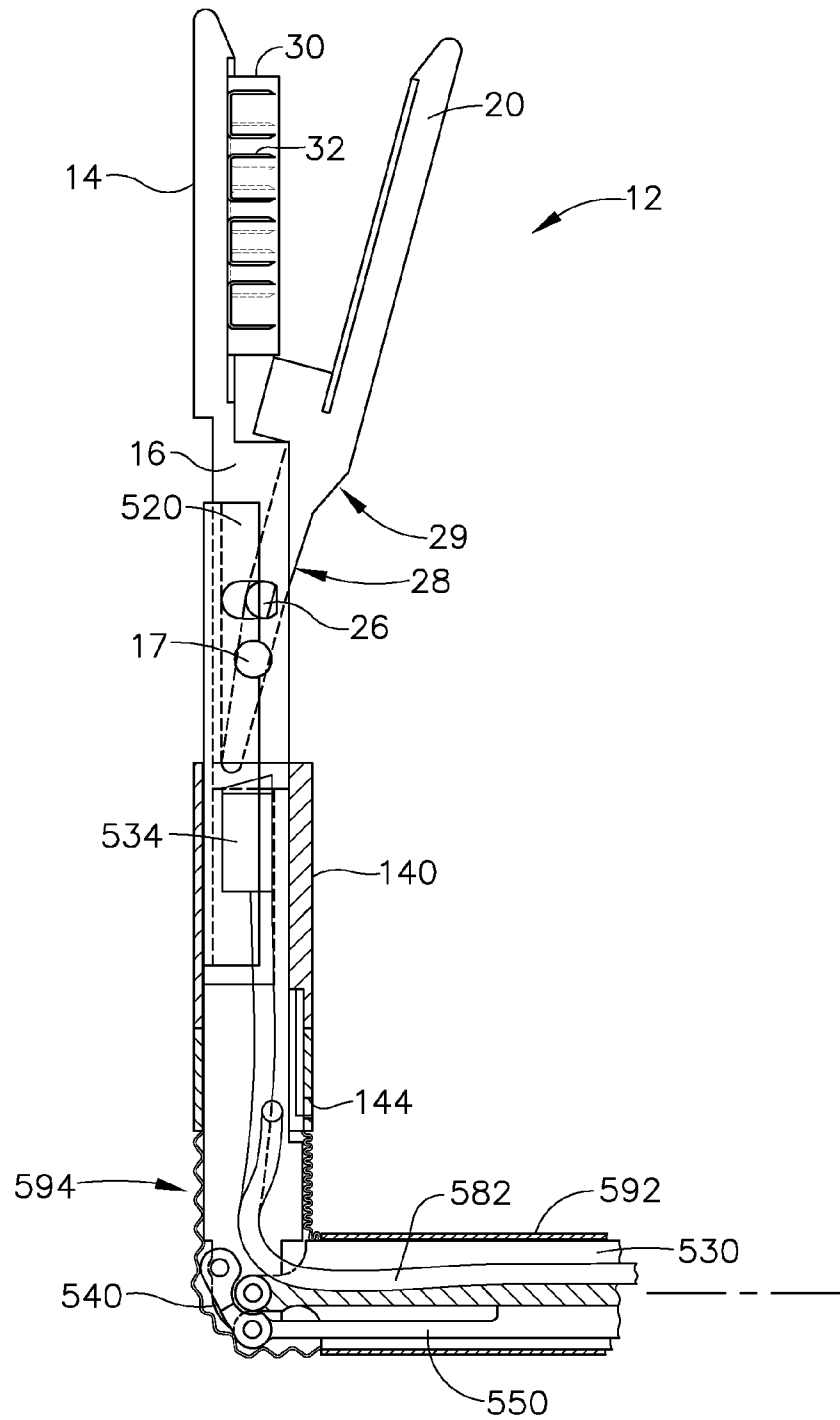


FIG. 48

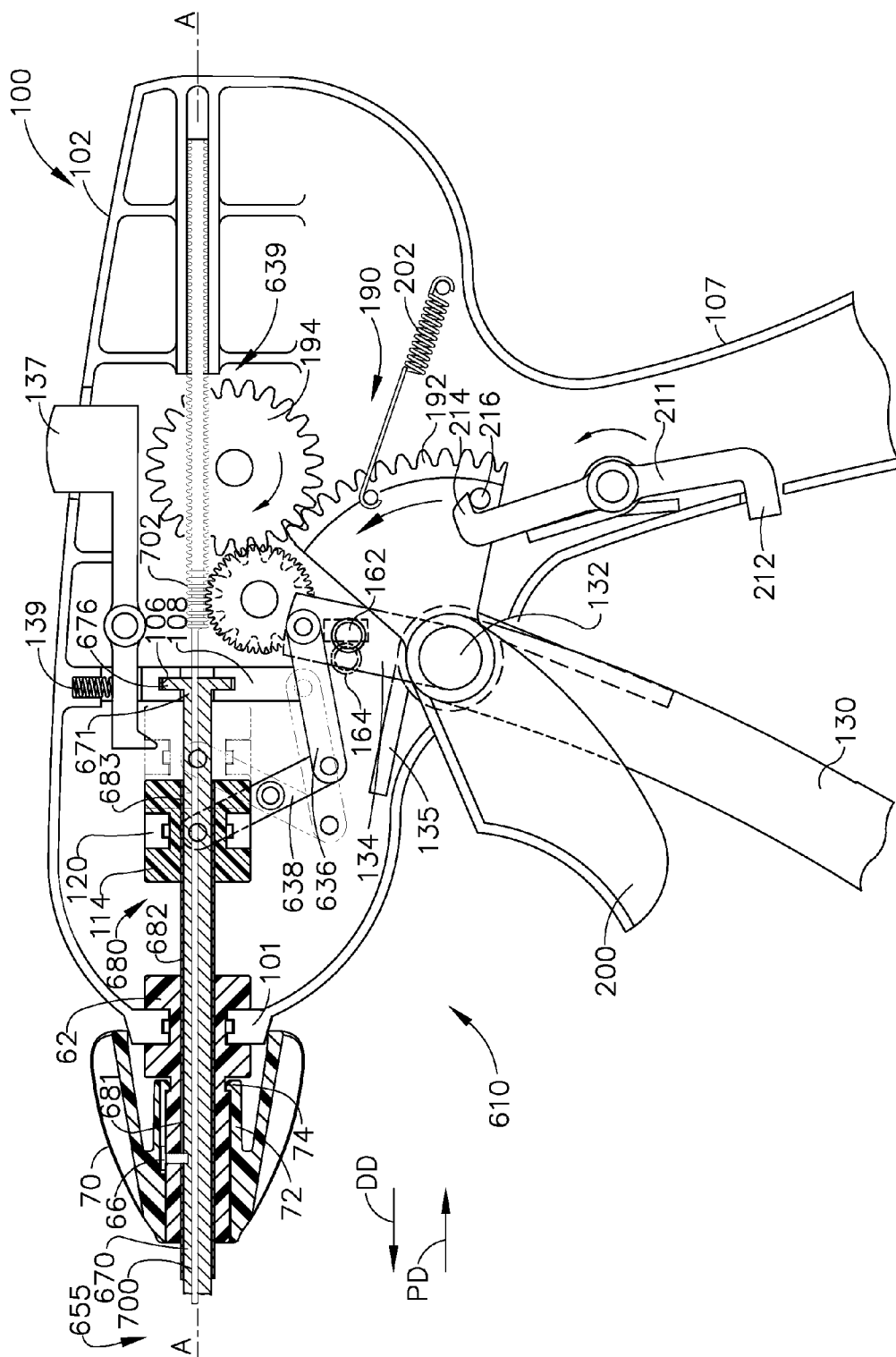
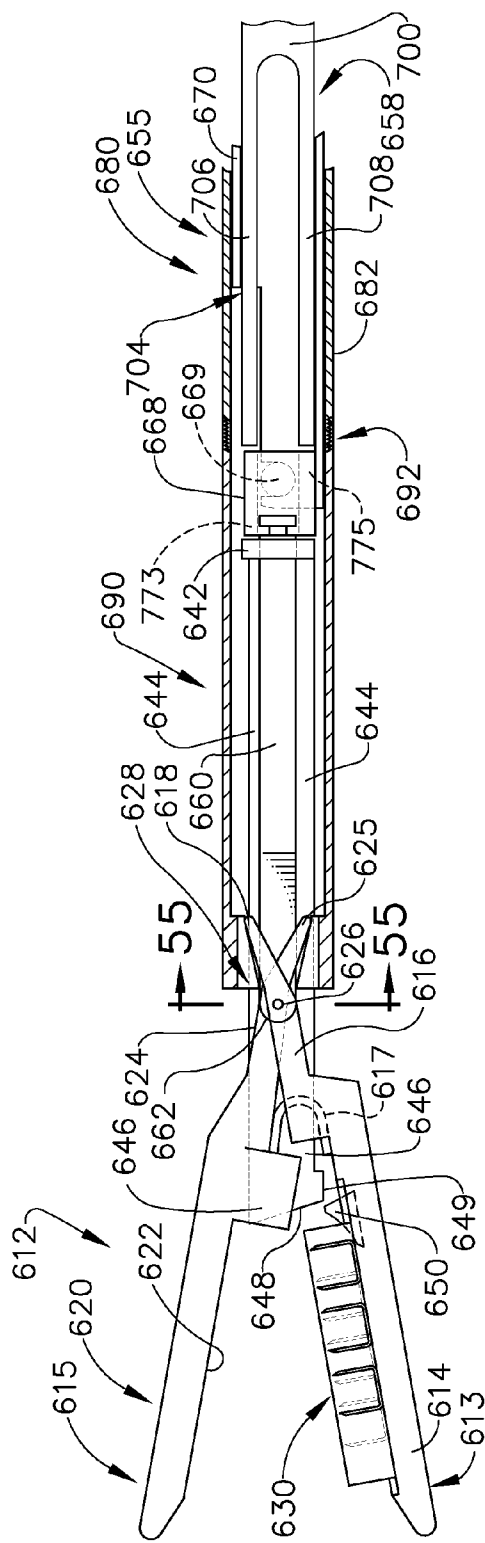
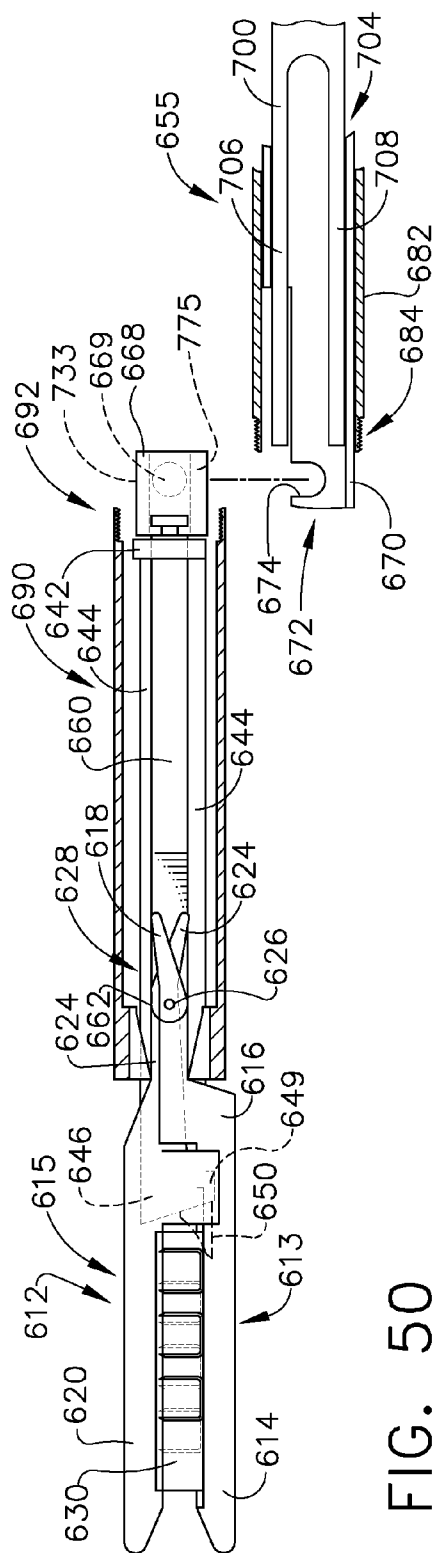


FIG. 49



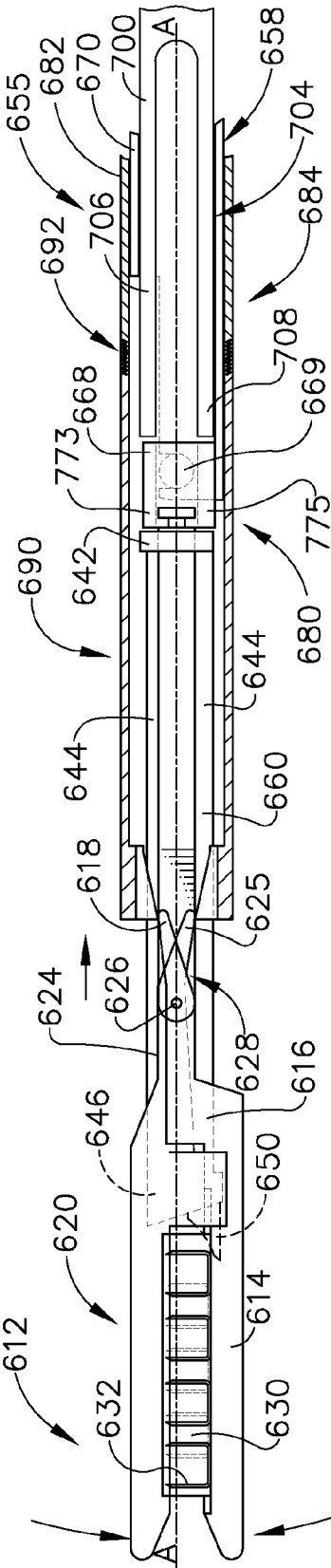


FIG. 52

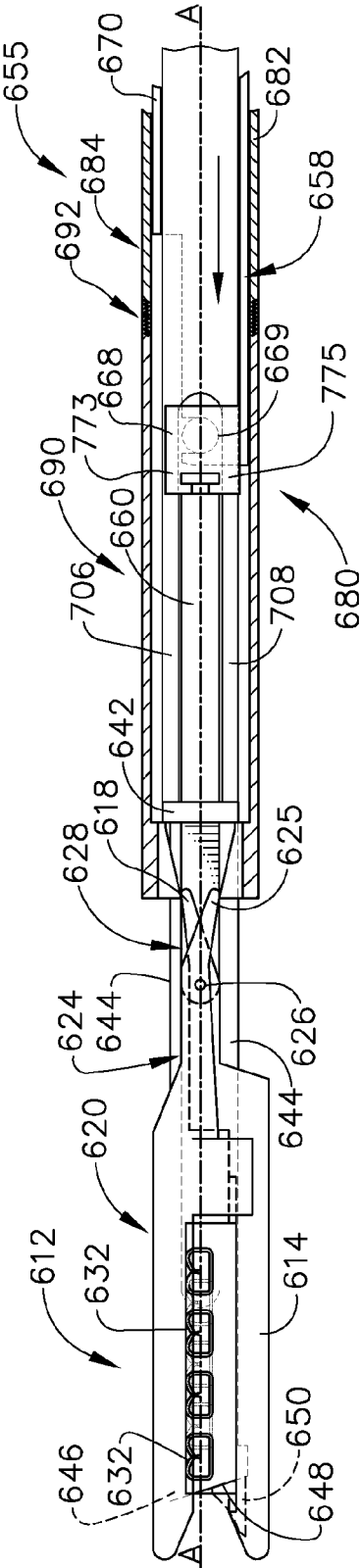


FIG. 53

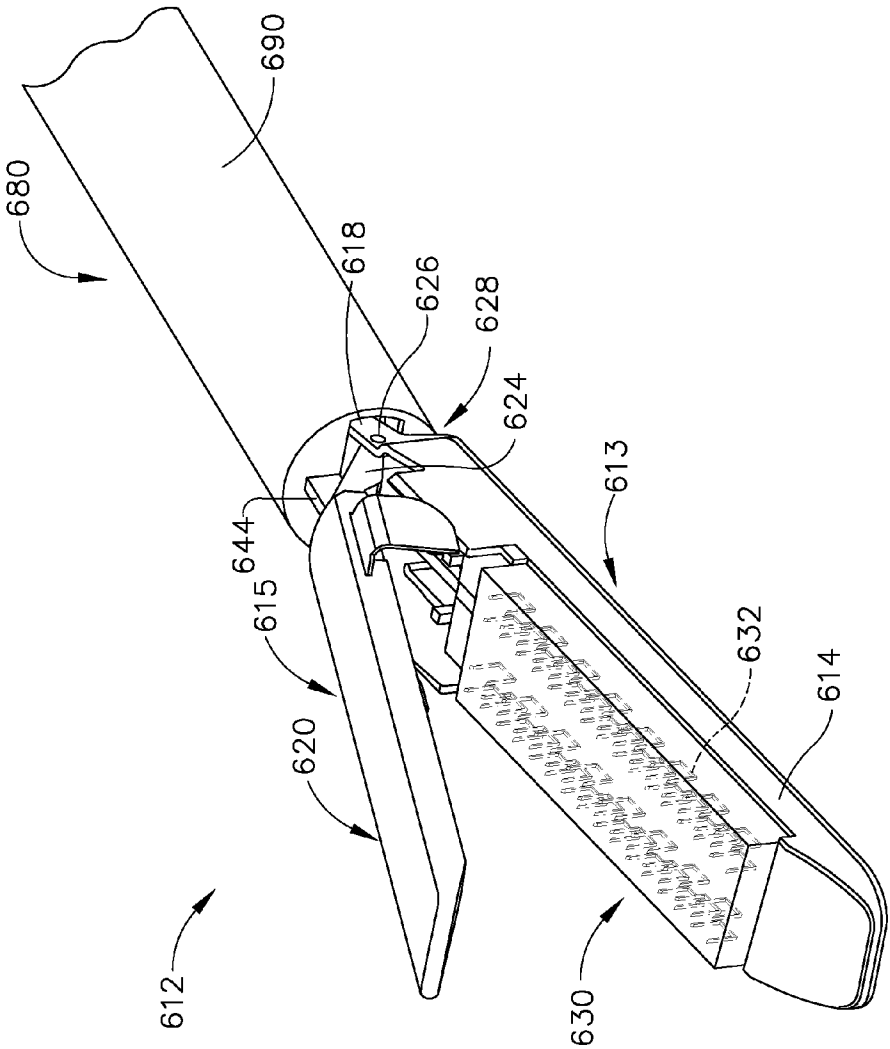


FIG. 54

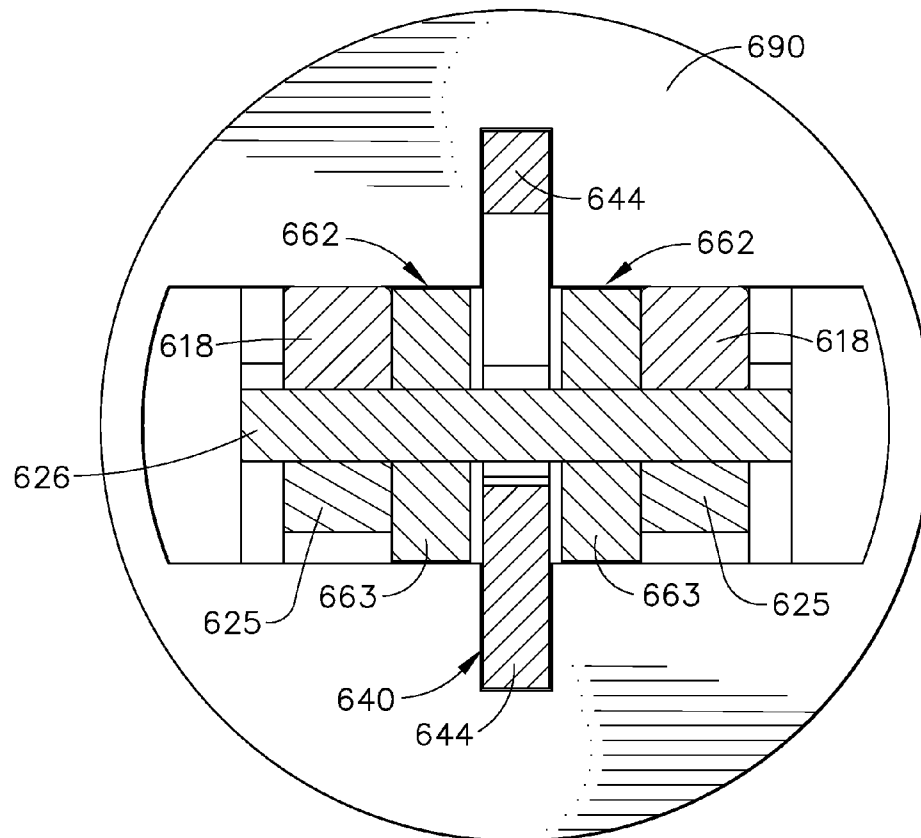


FIG. 55

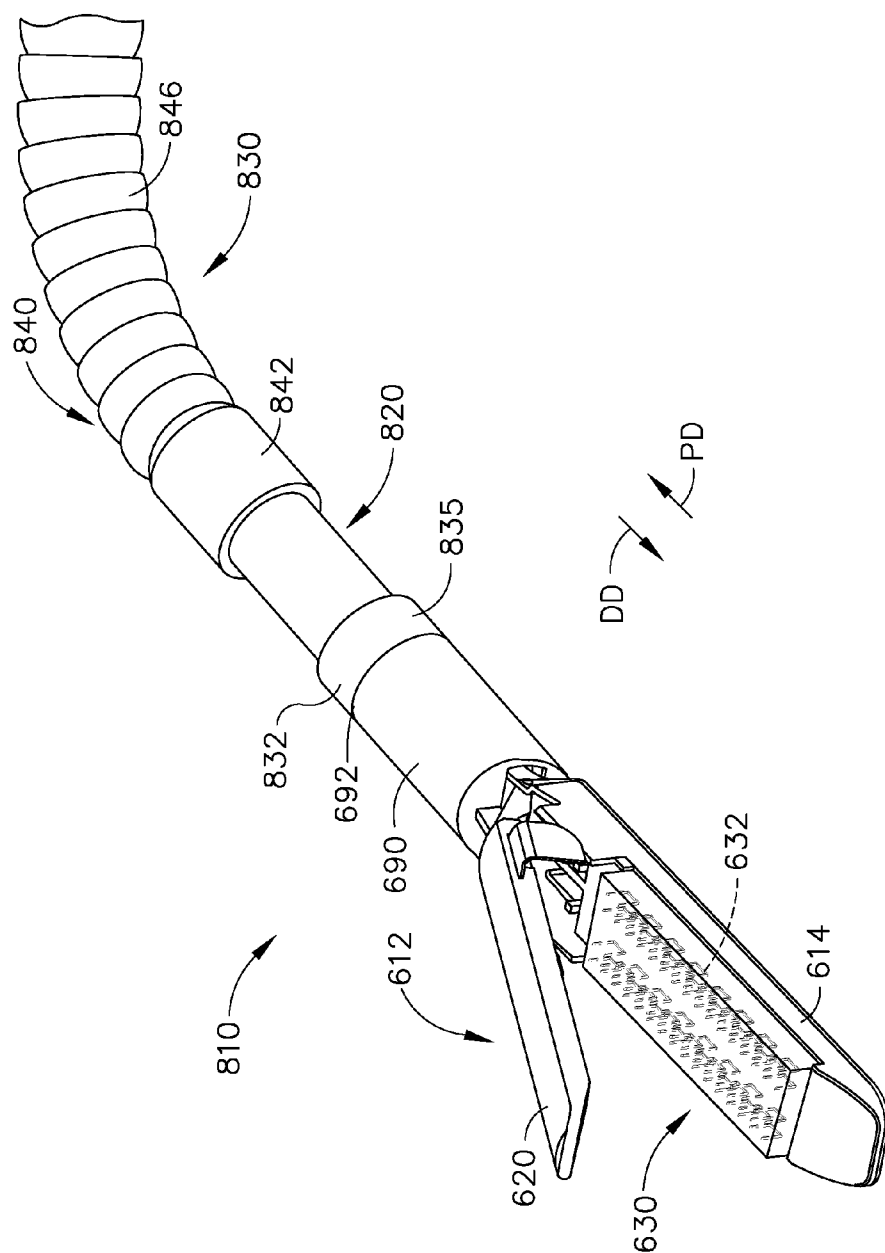


FIG. 56

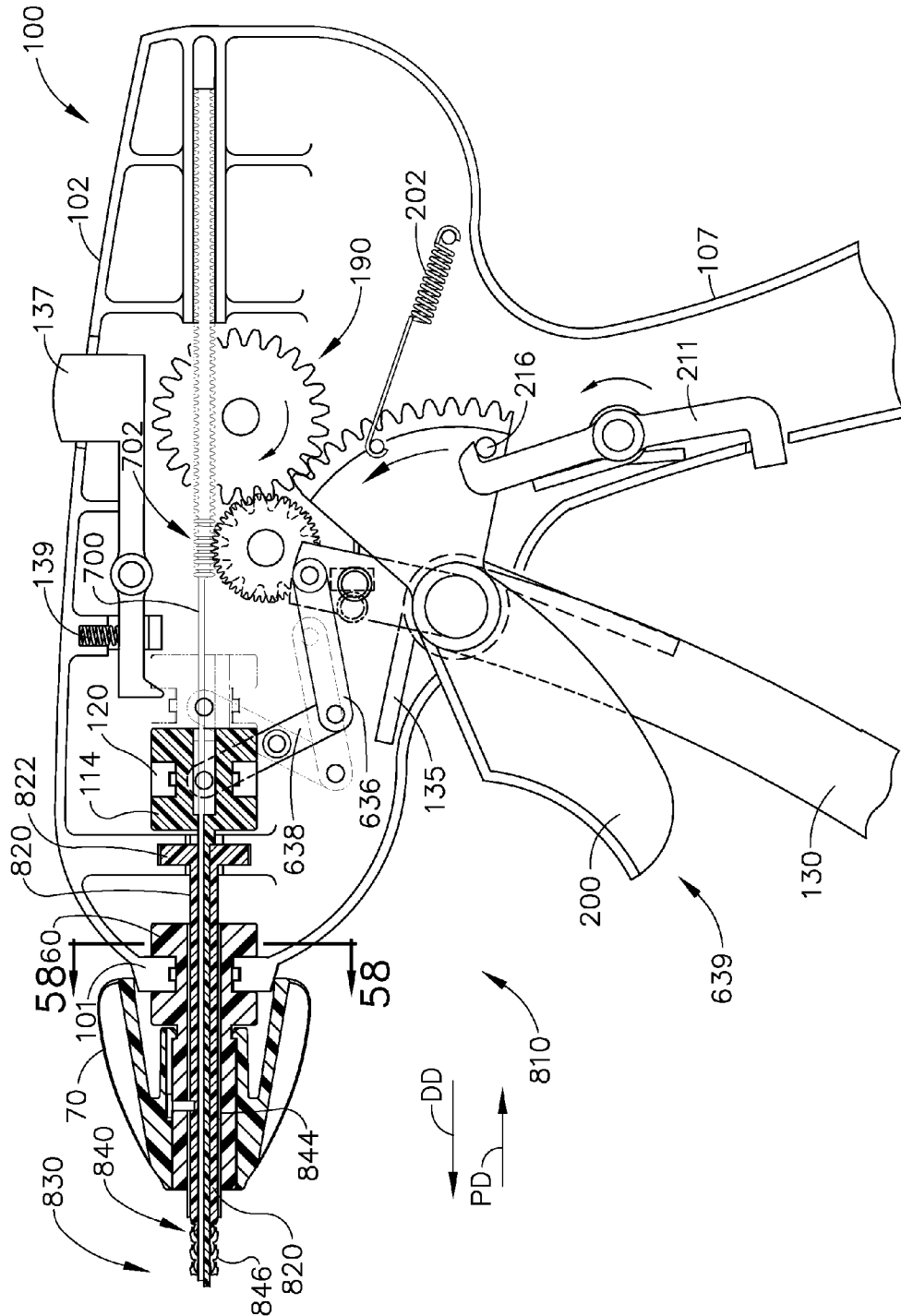


FIG. 57

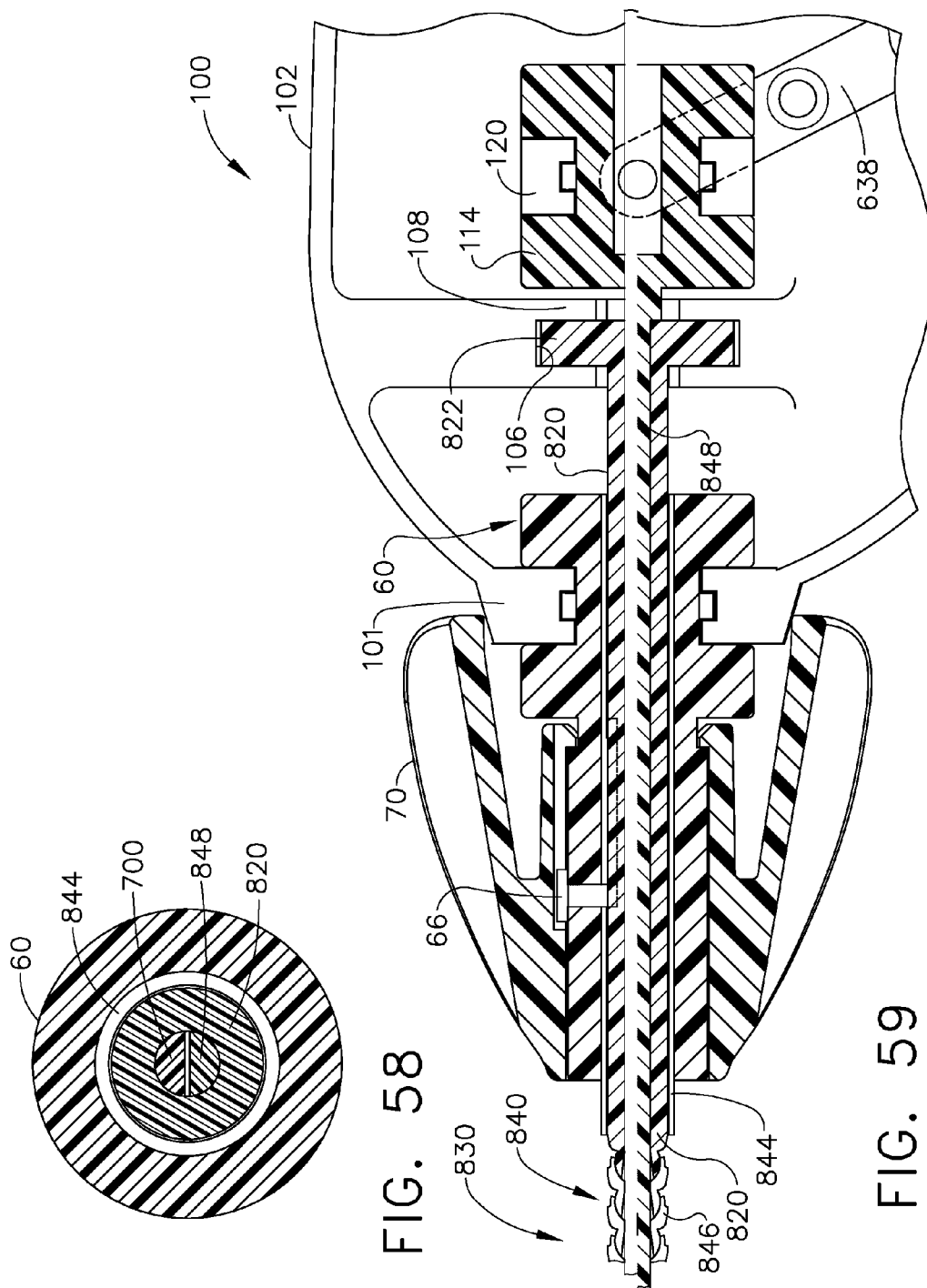


FIG. 58

FIG. 59

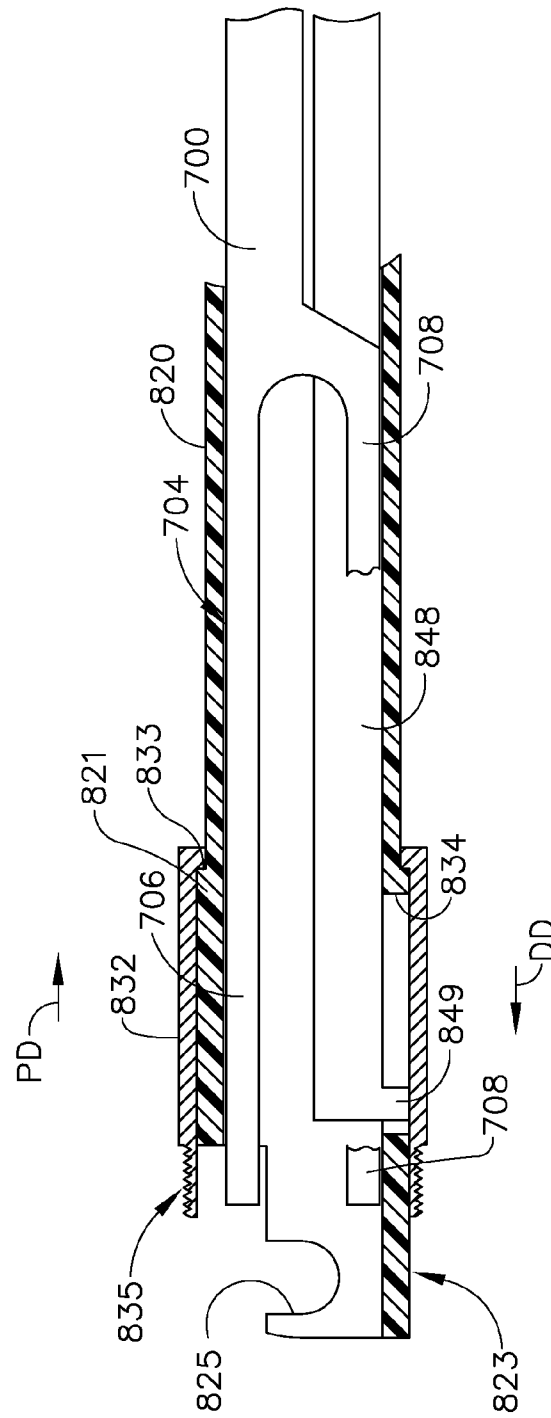


FIG. 60

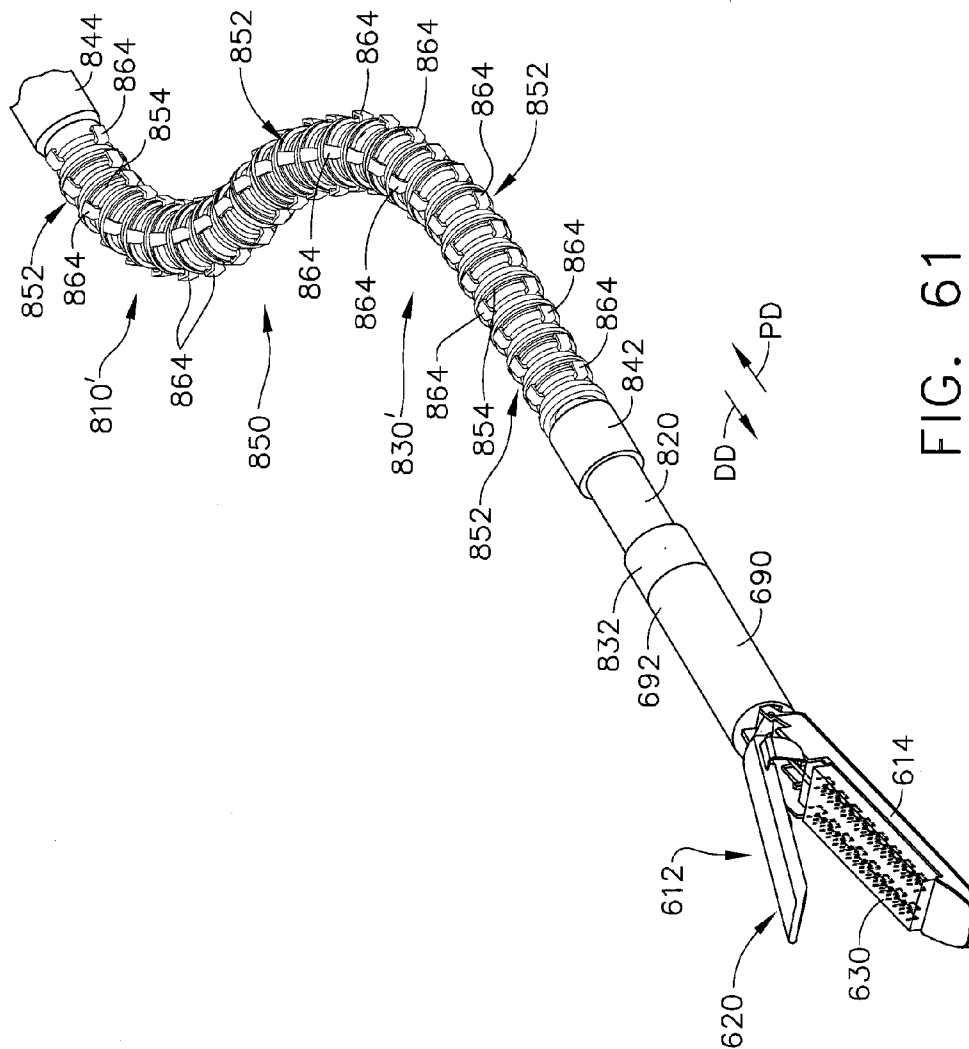


FIG. 61

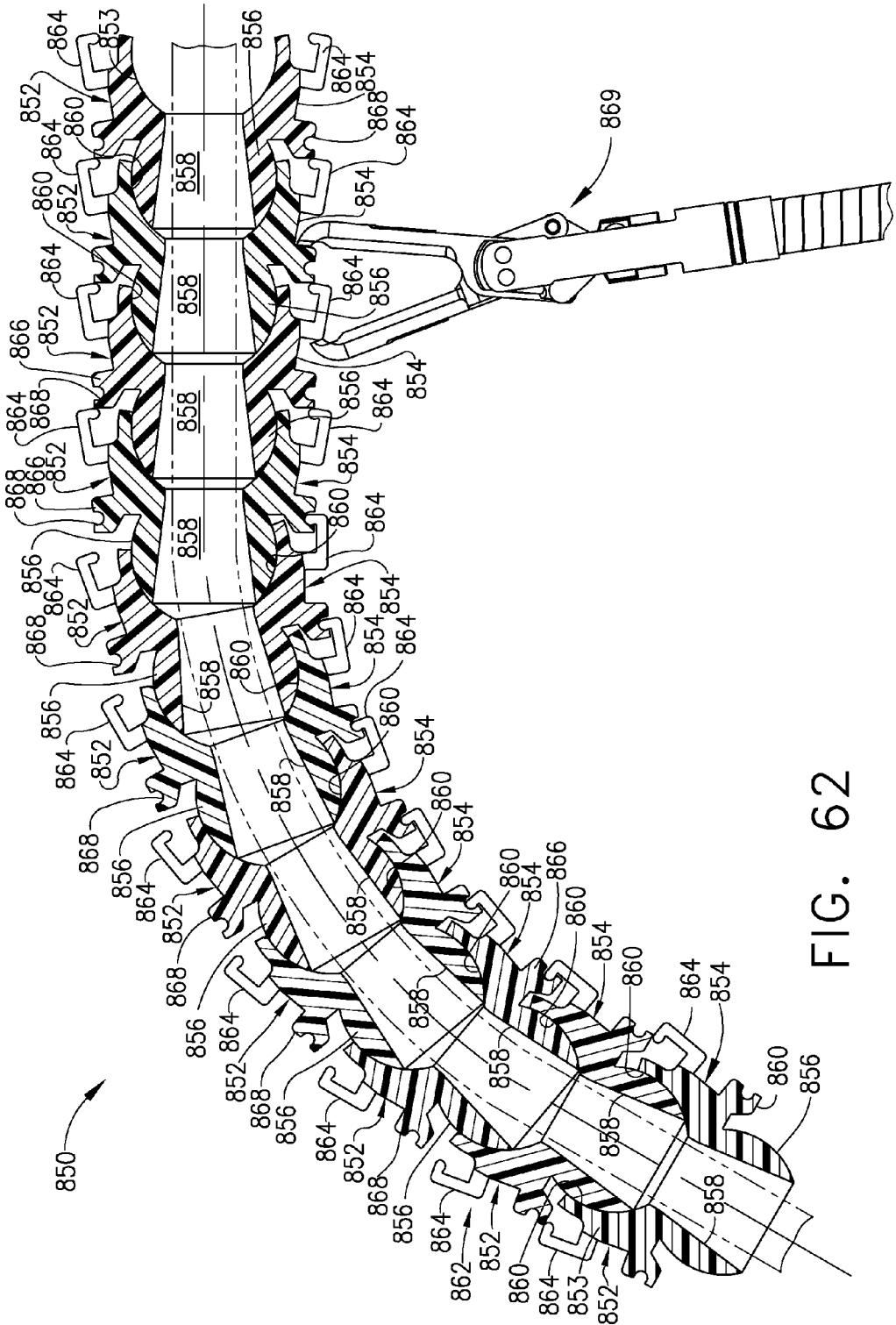


FIG. 62

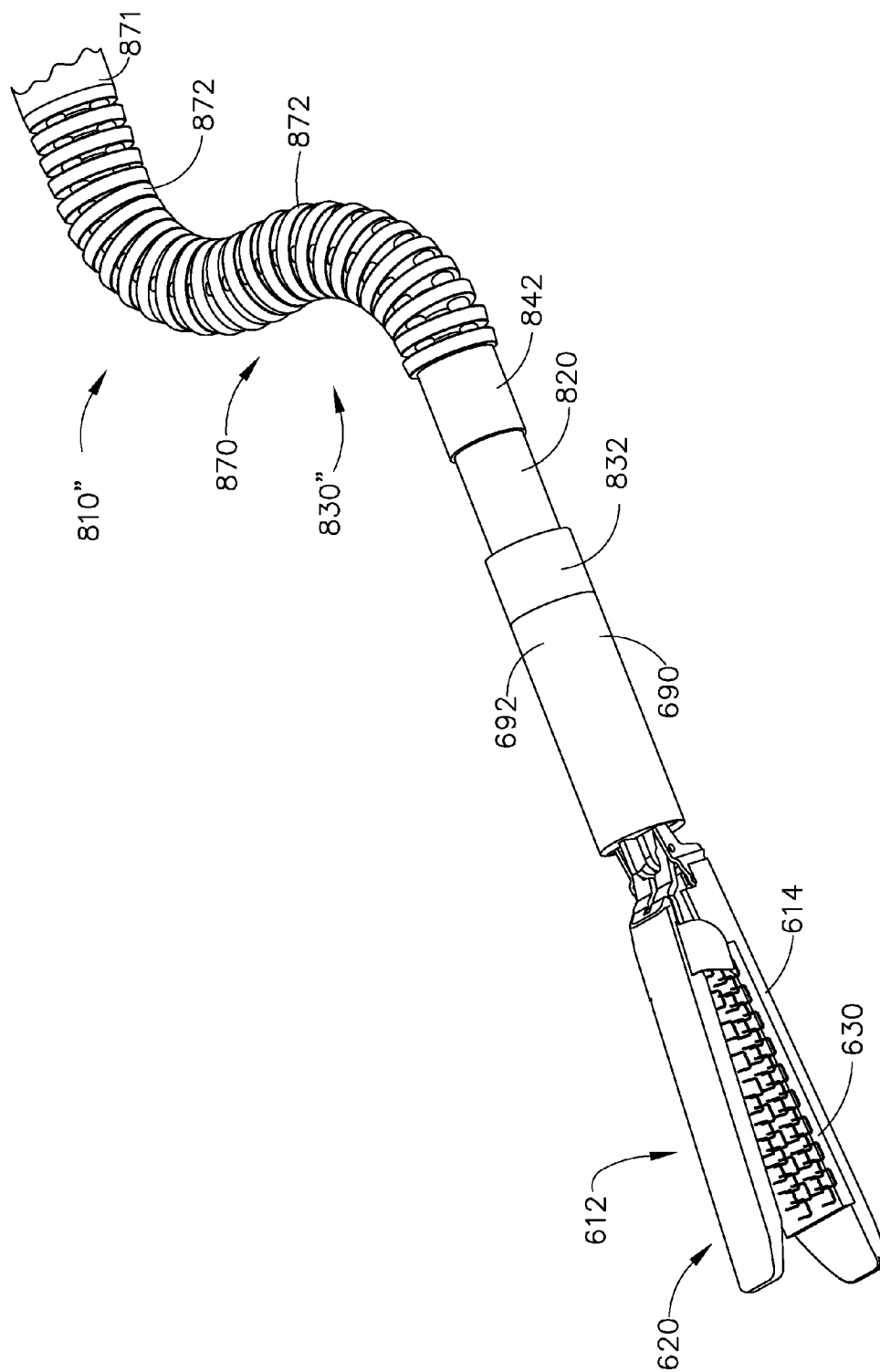


FIG. 63

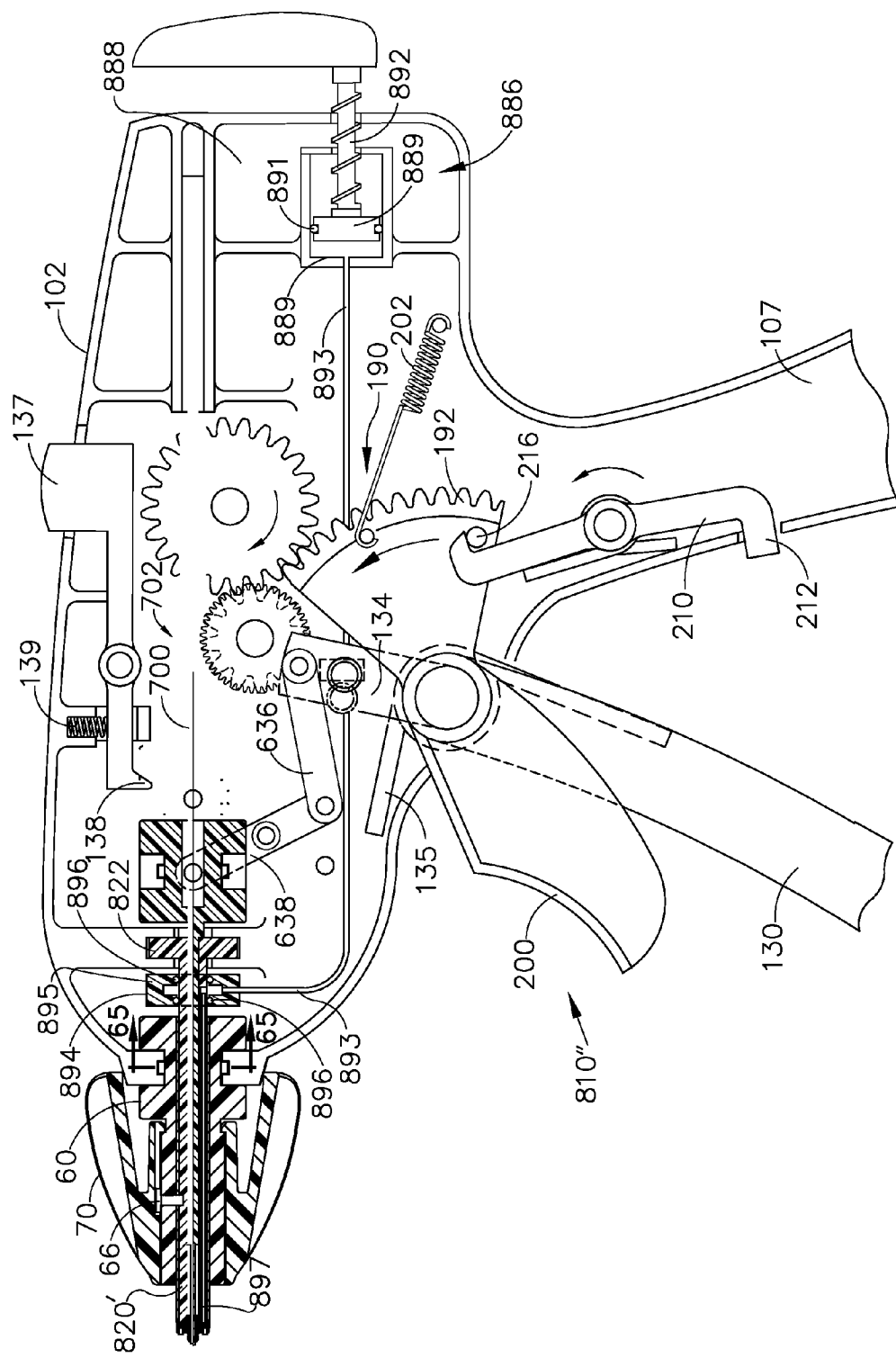
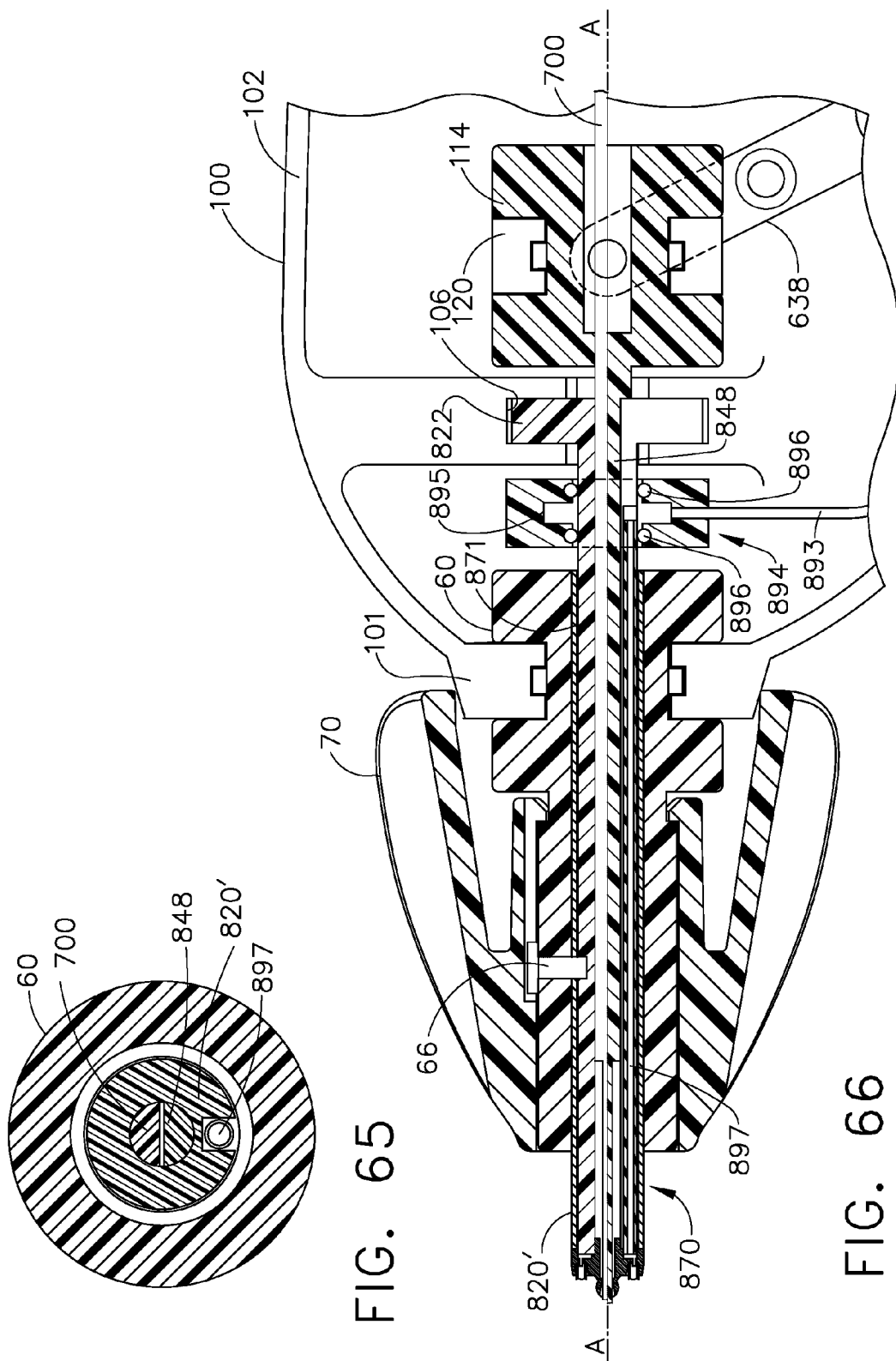


FIG. 64



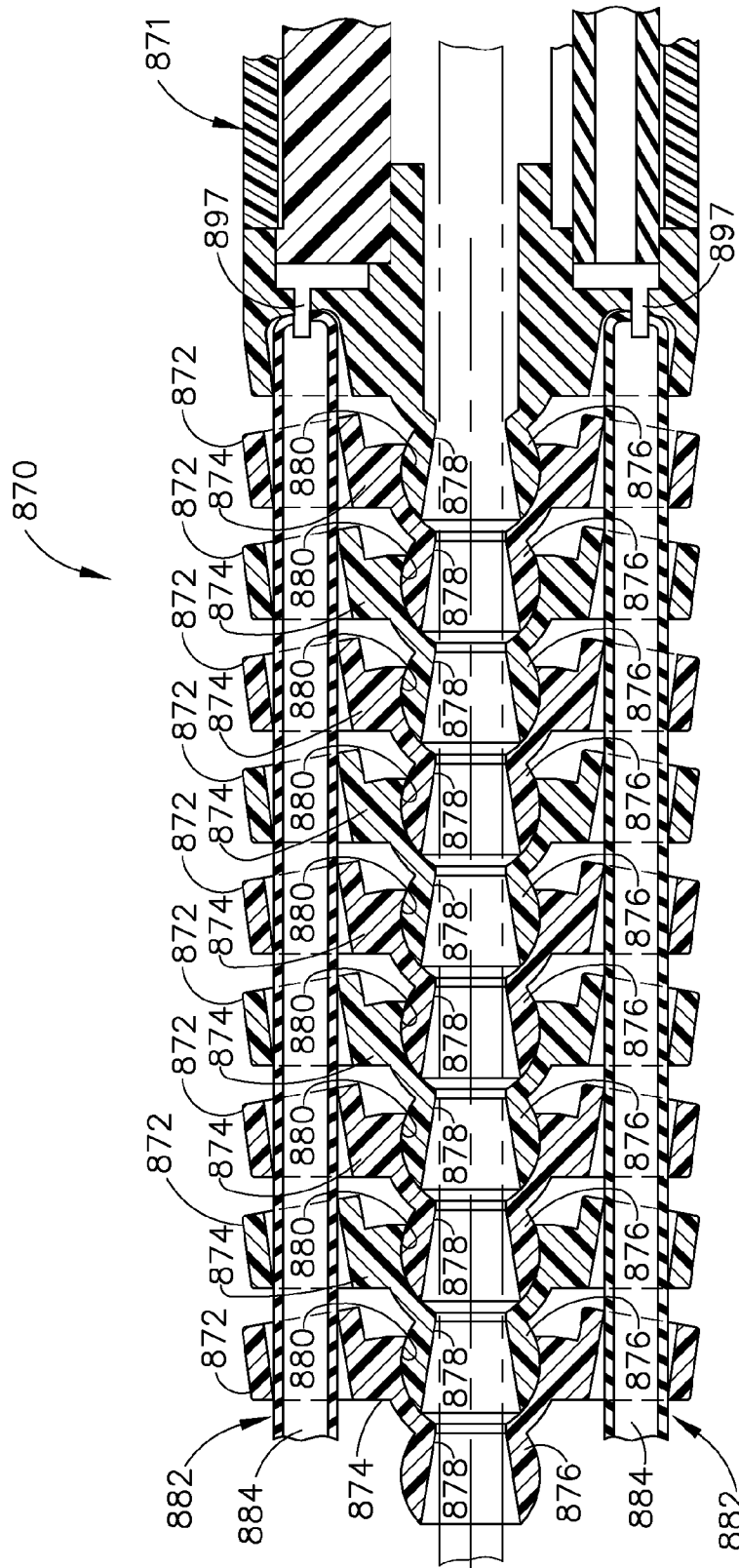


FIG. 67

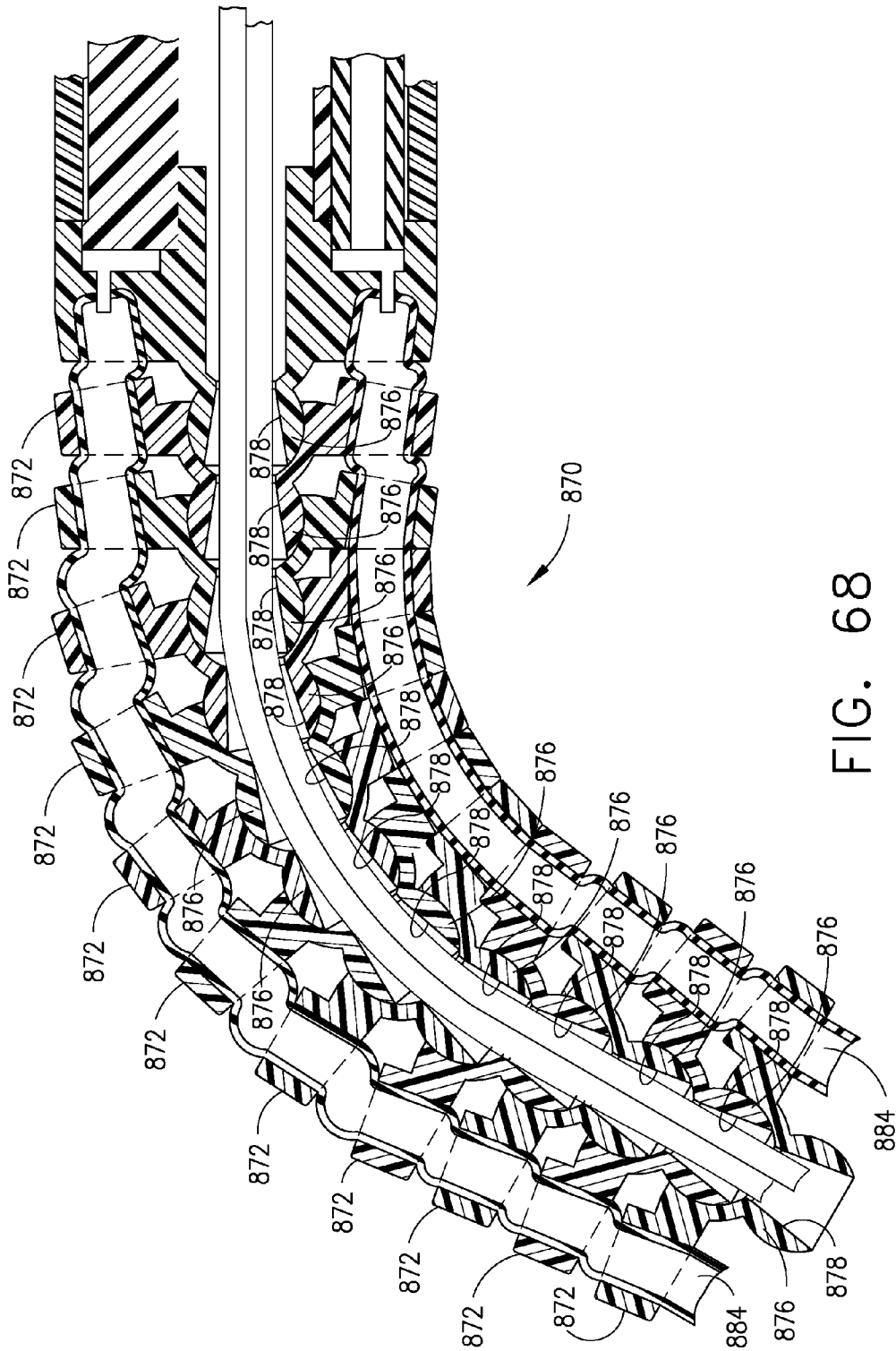


FIG. 68

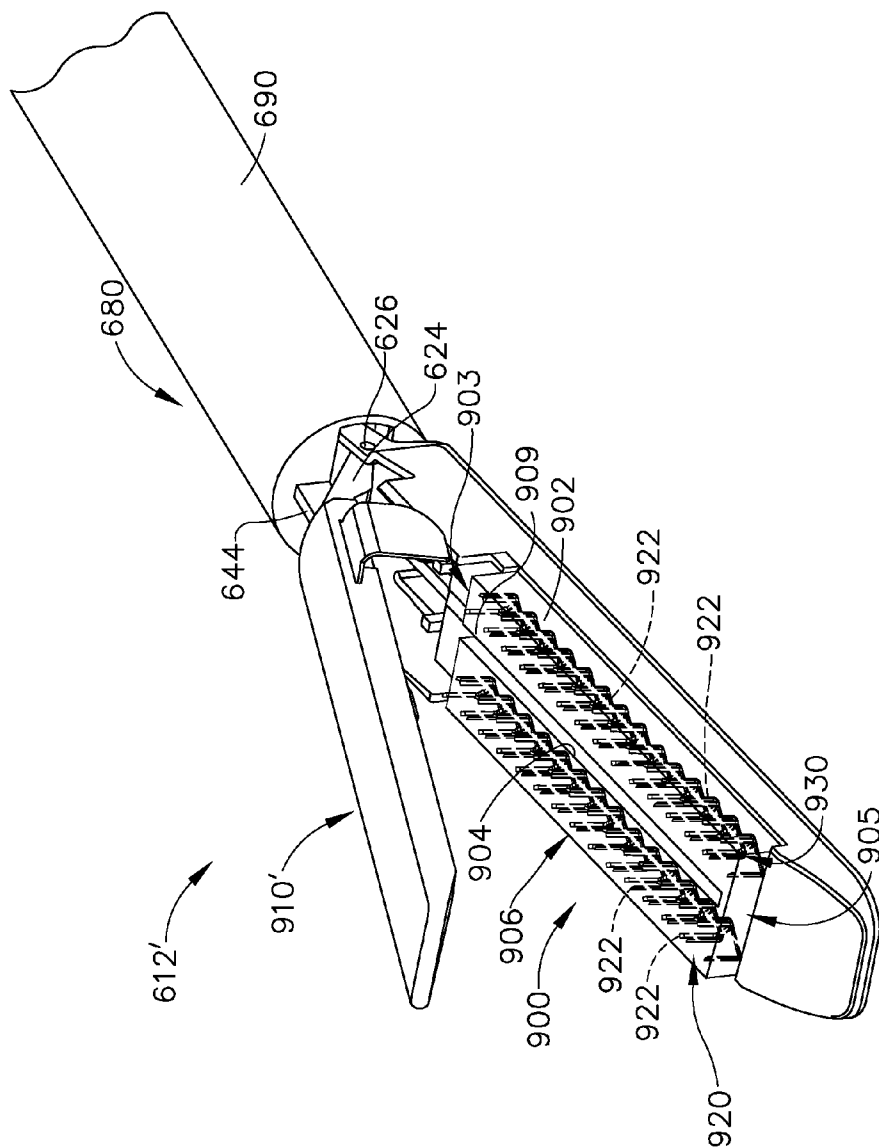


FIG. 69

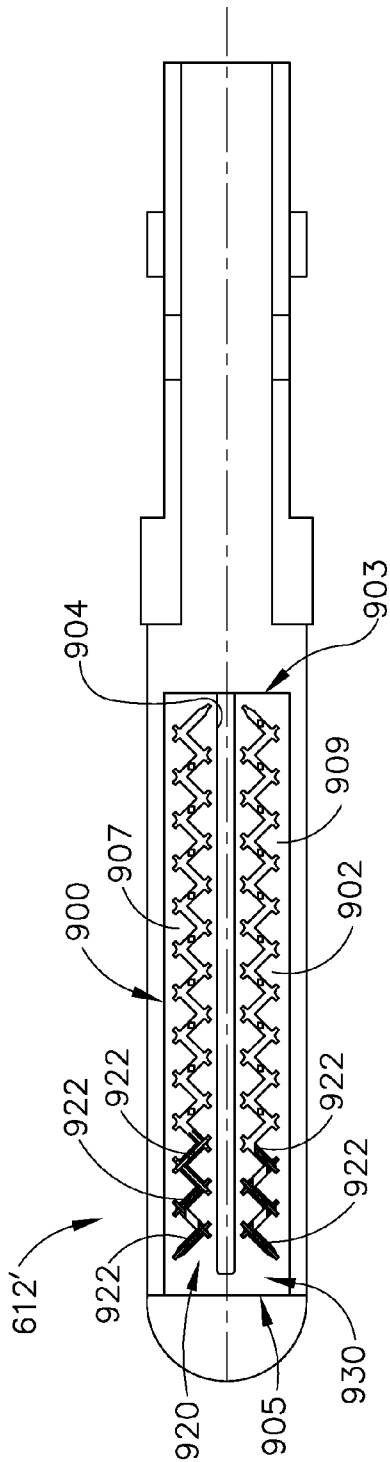


FIG. 70

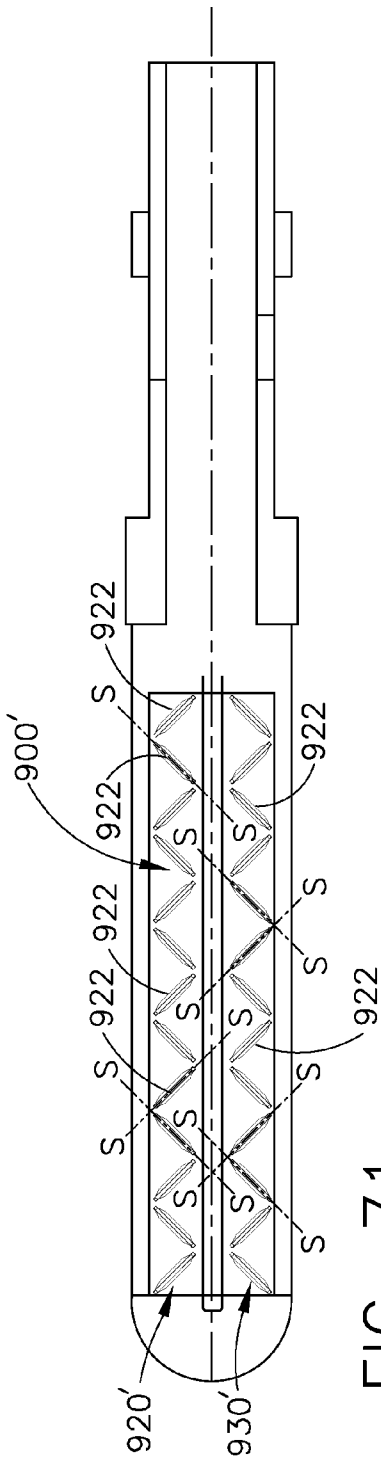


FIG. 71

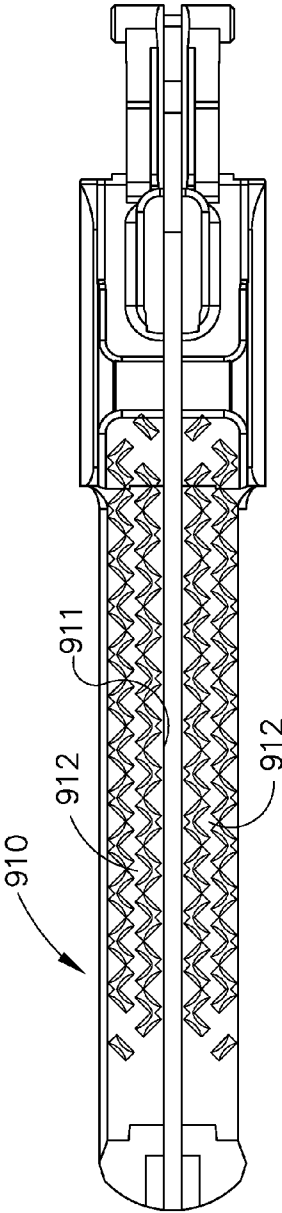


FIG. 72

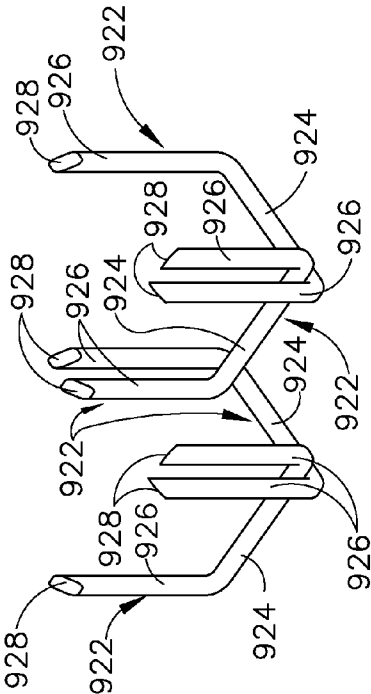


FIG. 73

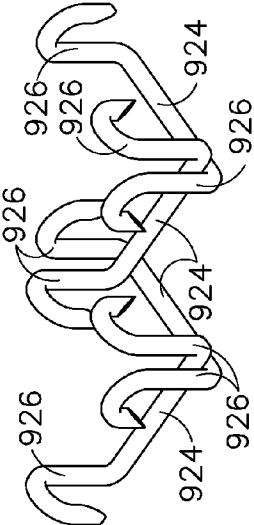


FIG. 74

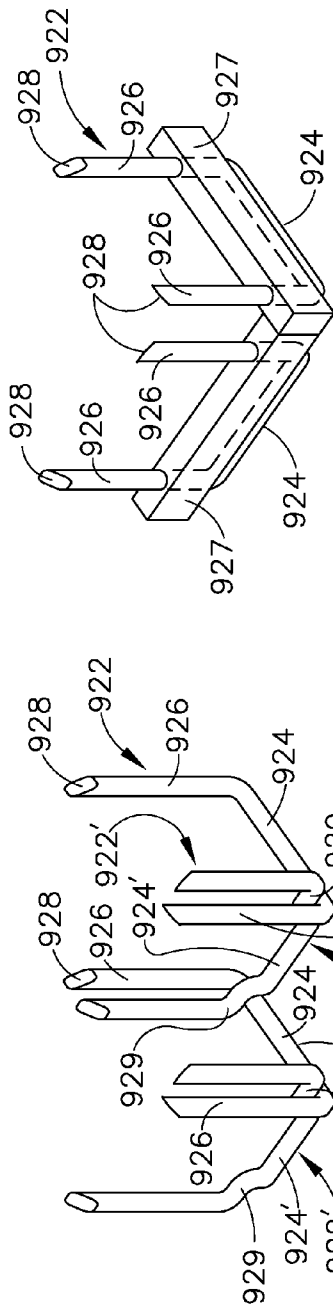


FIG. 76

FIG. 75

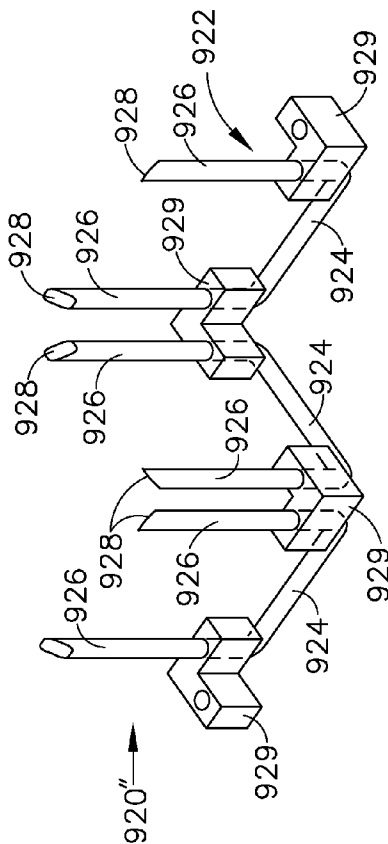


FIG. 77

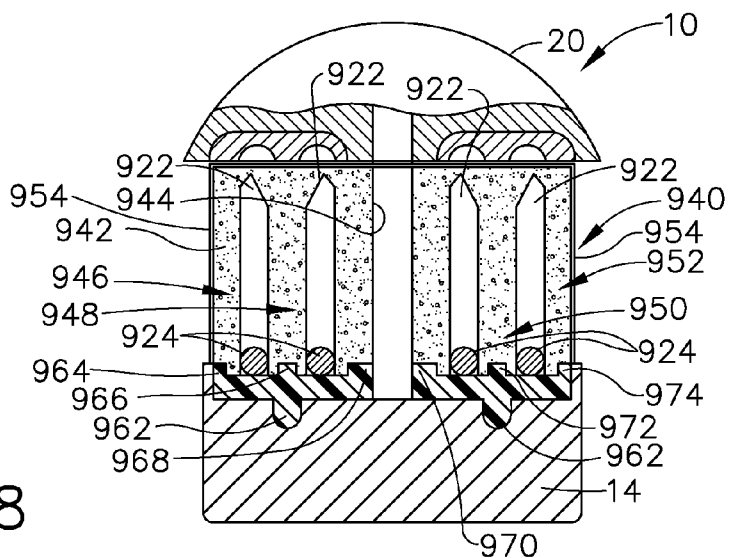


FIG. 78

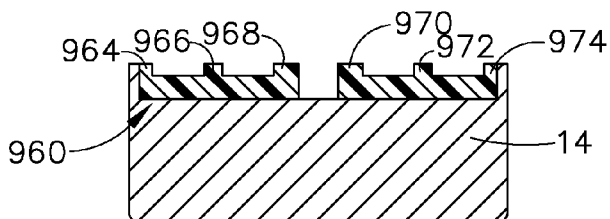


FIG. 79

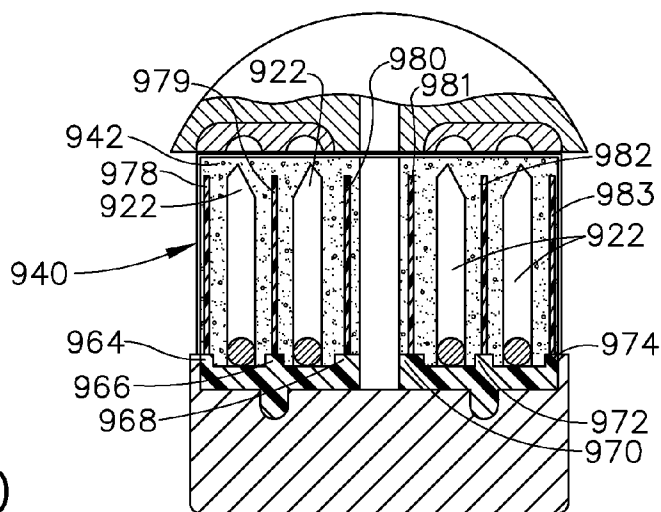


FIG. 80

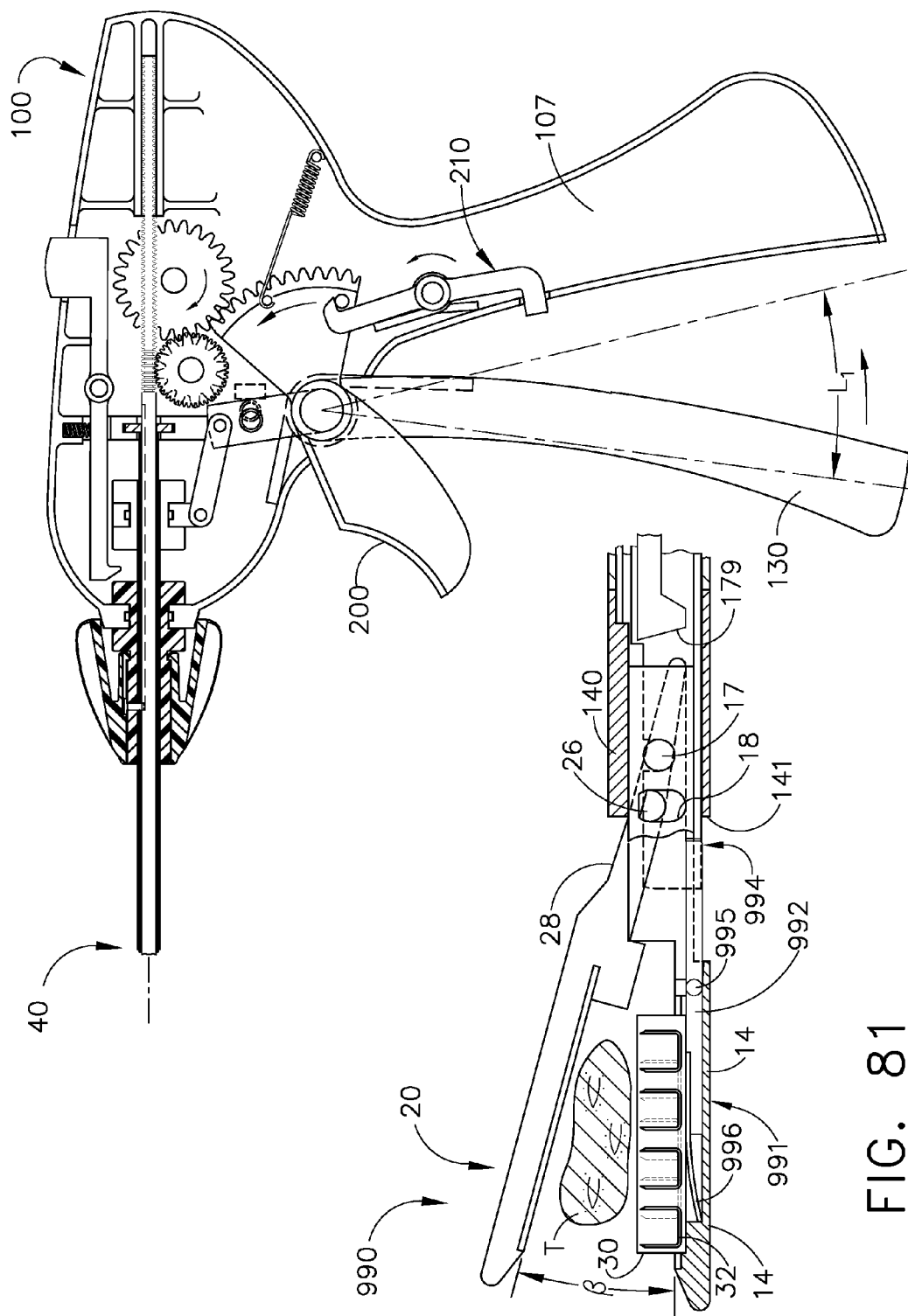


FIG. 81

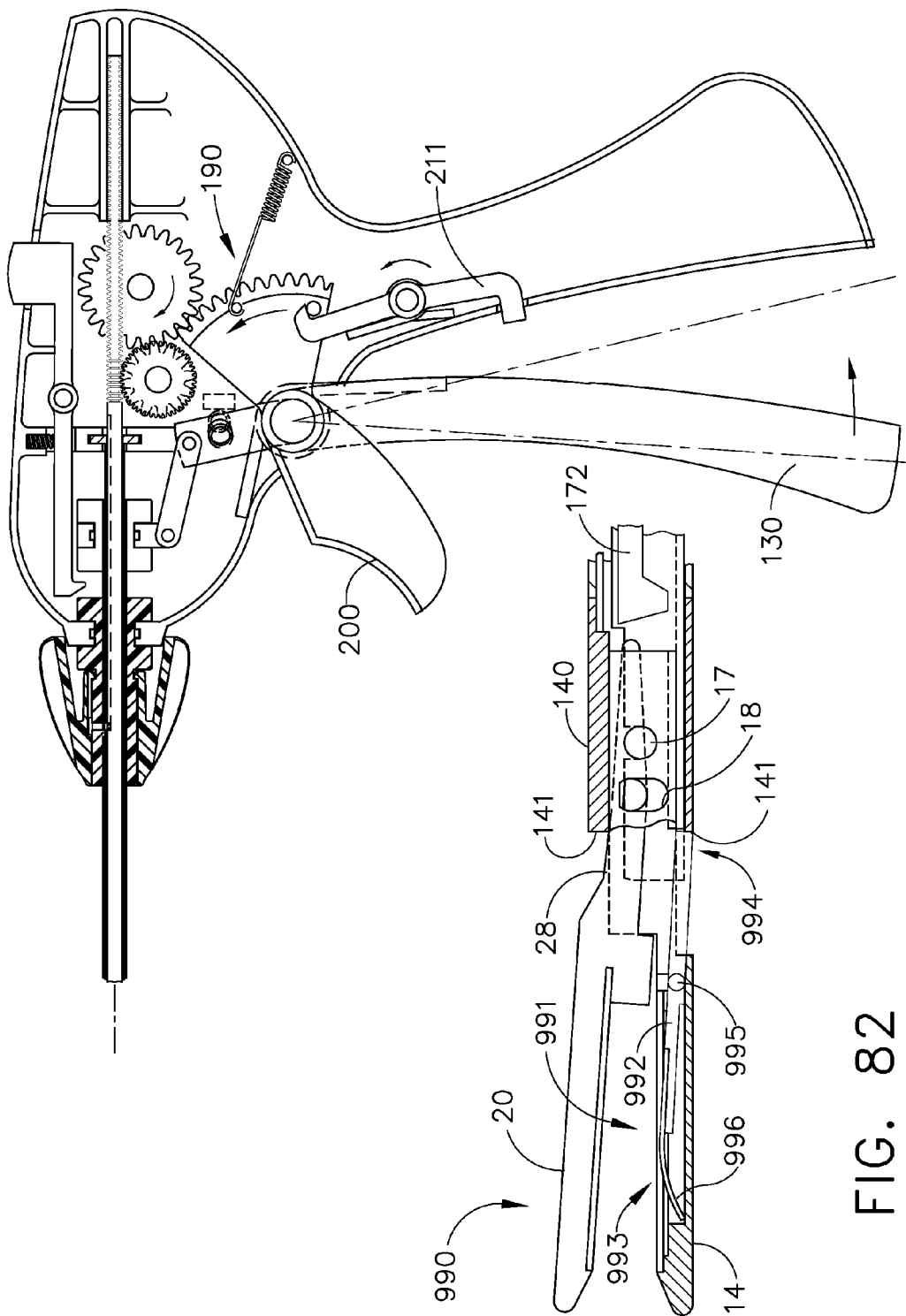
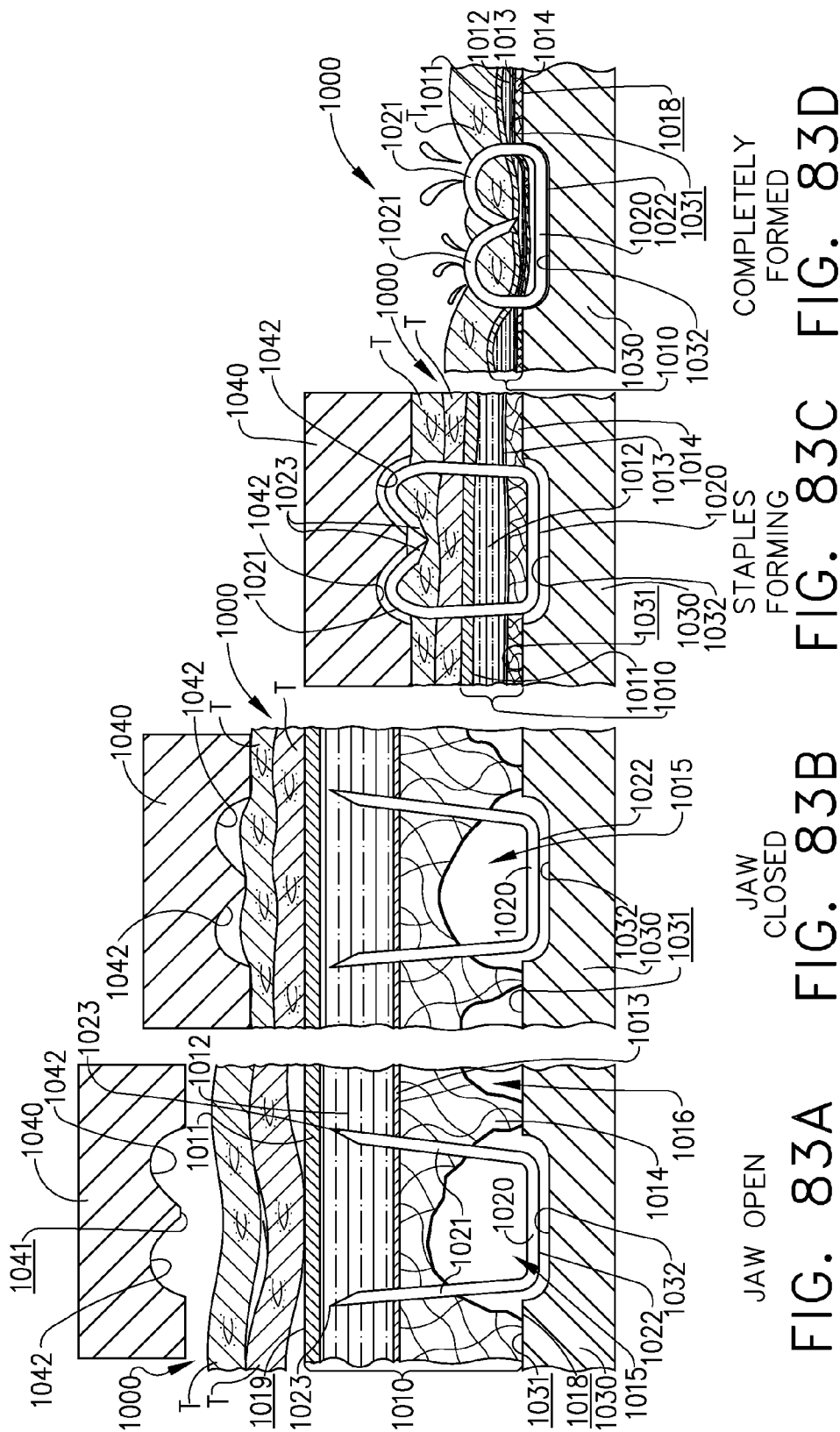


FIG. 82



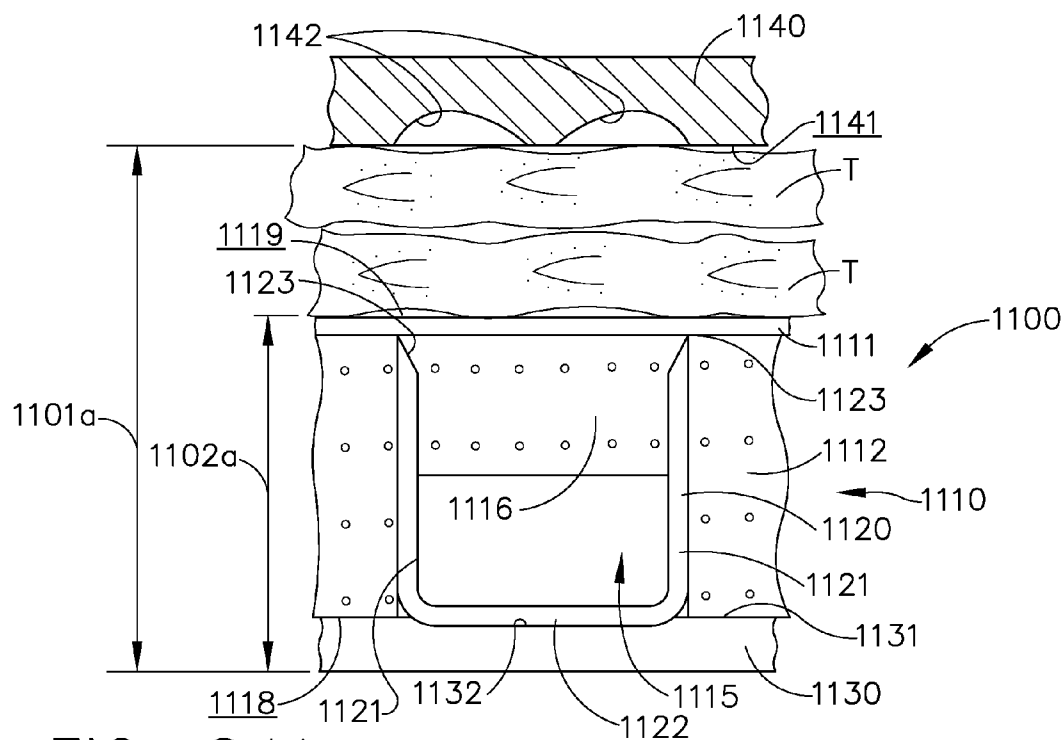


FIG. 84A

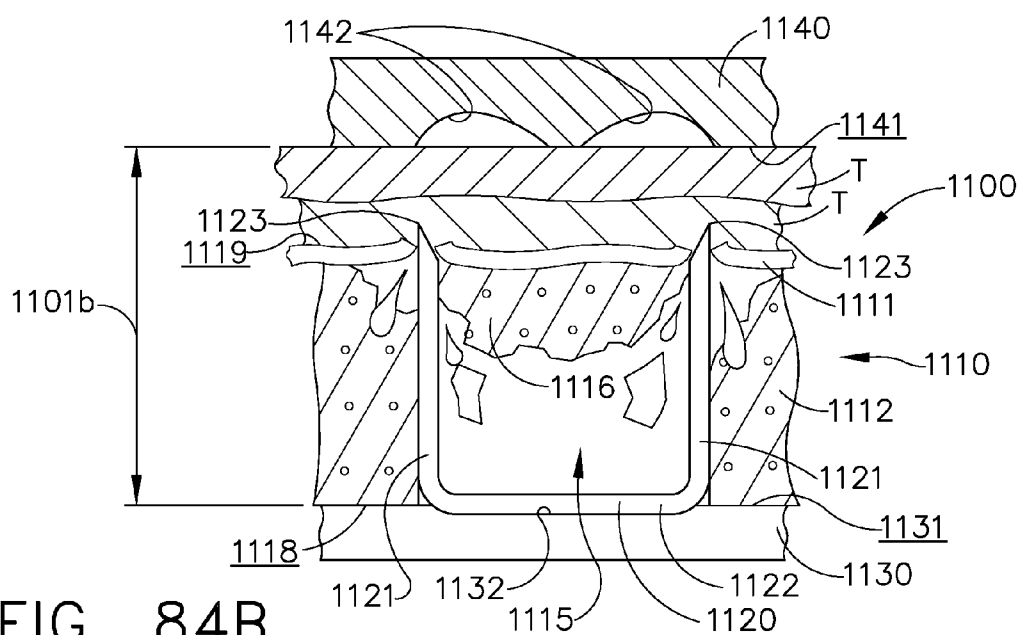


FIG. 84B

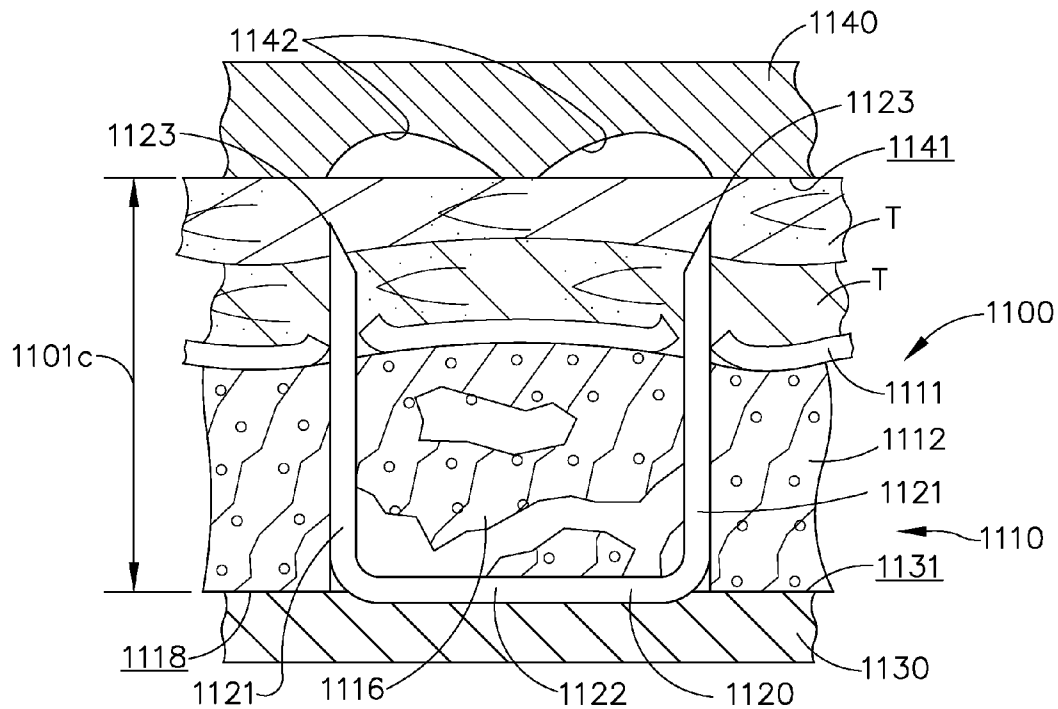


FIG. 84C

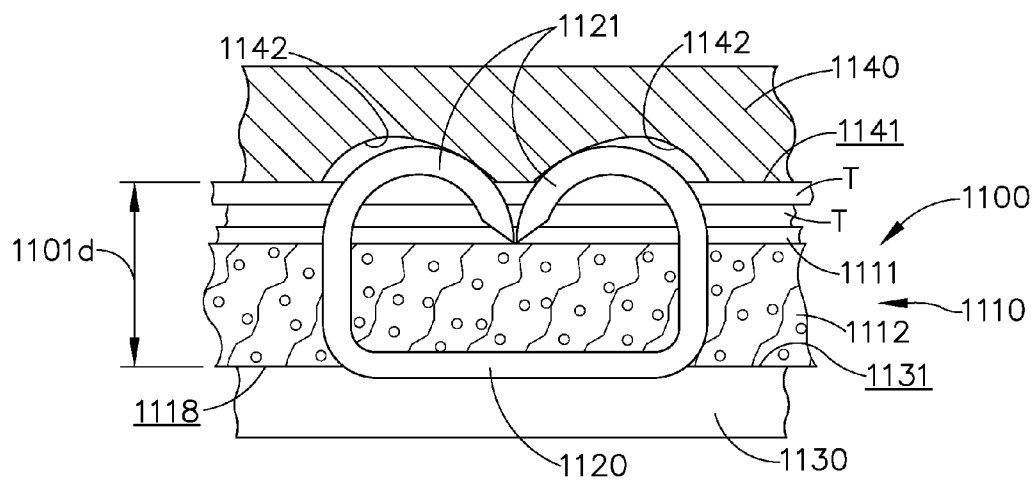
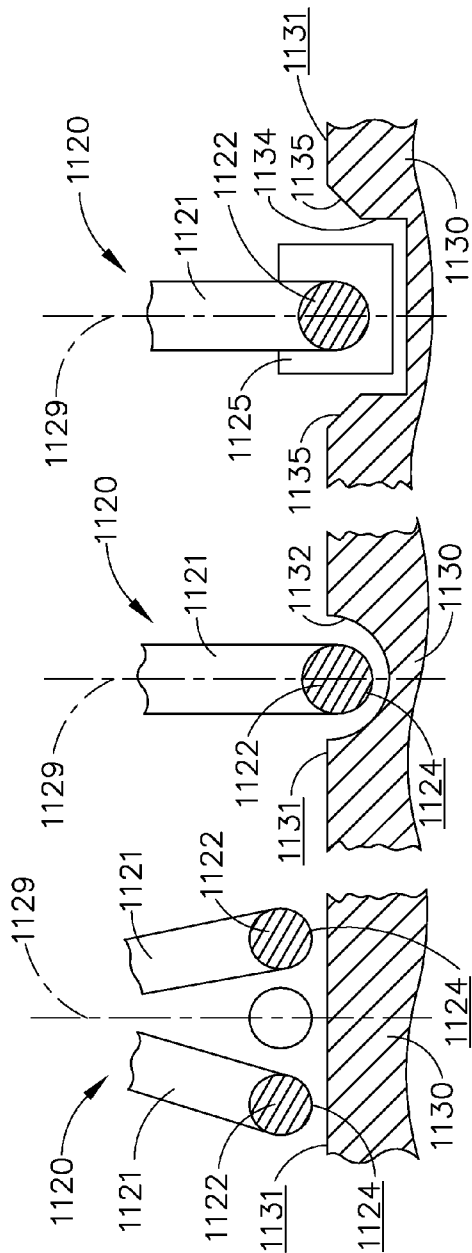
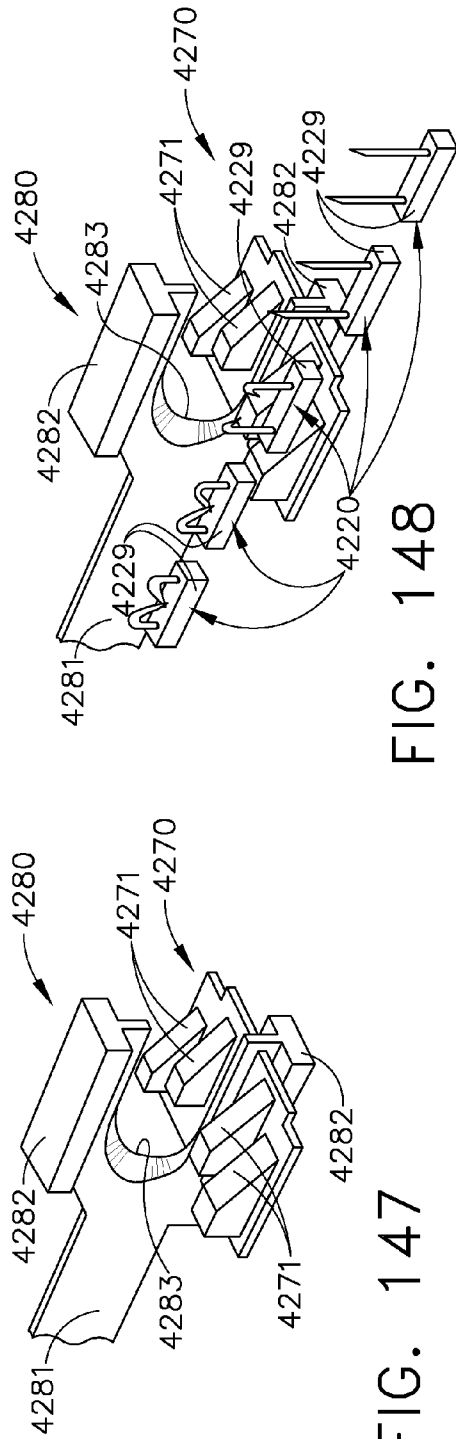


FIG. 84D



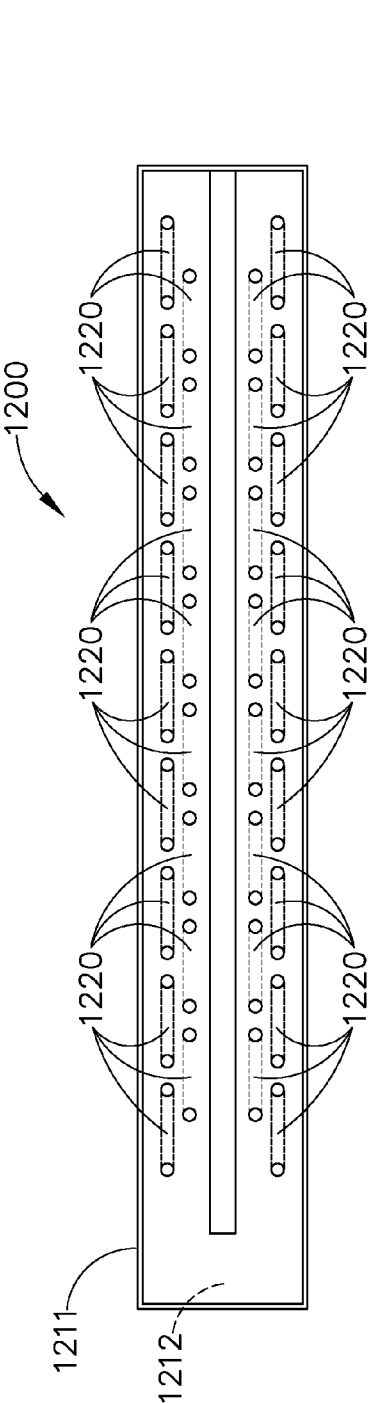


FIG. 88

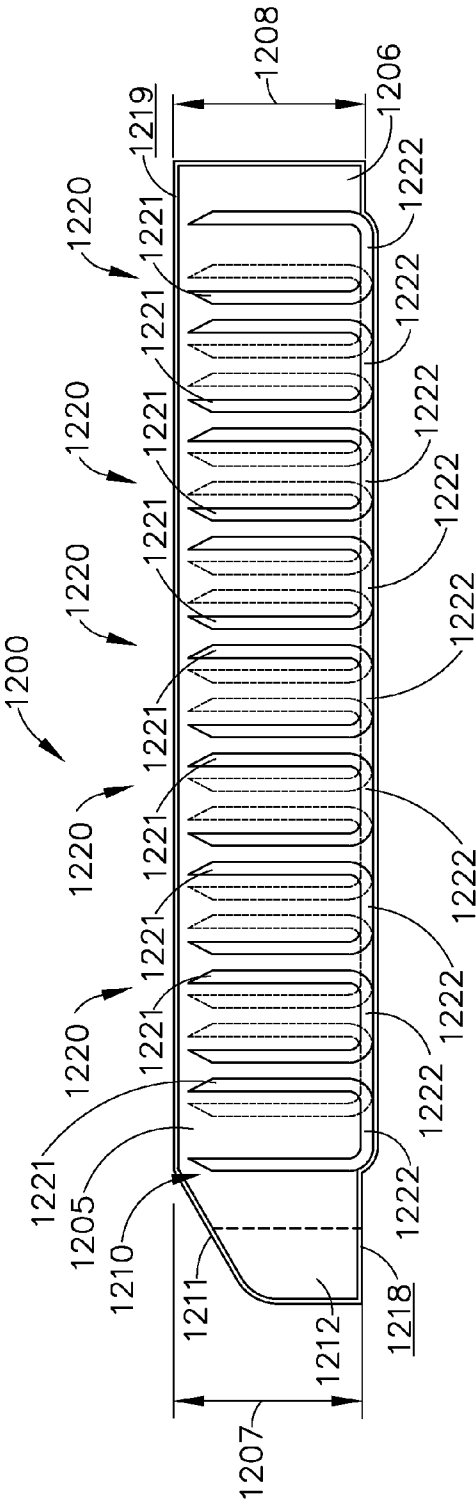


FIG. 89

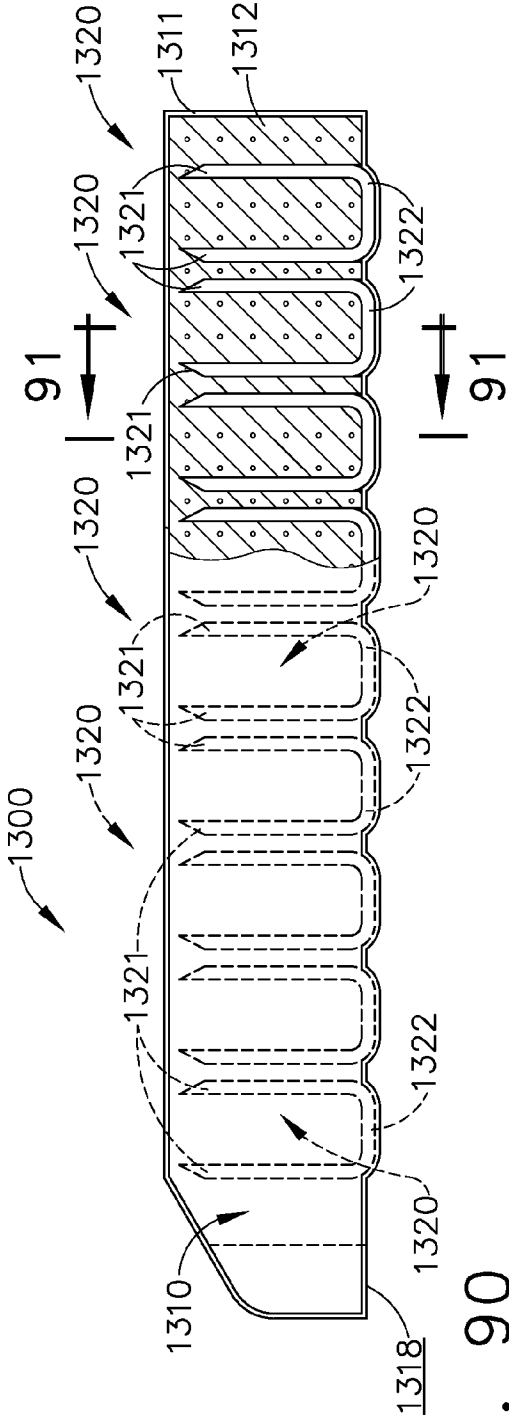


FIG. 90

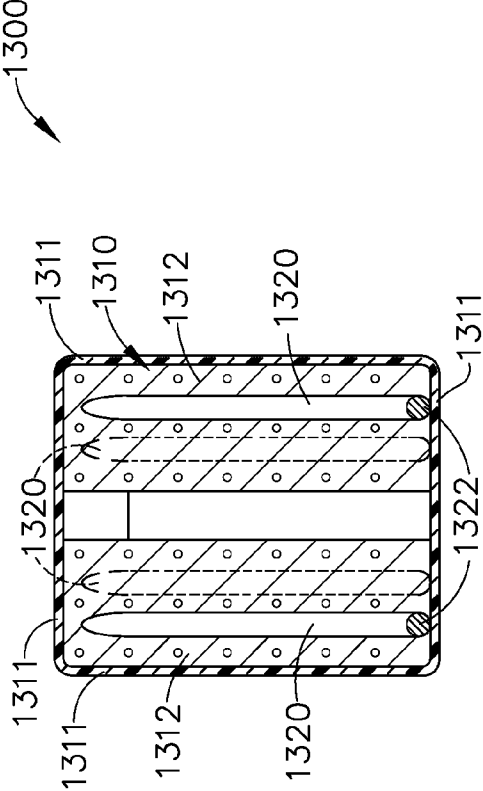


FIG. 91

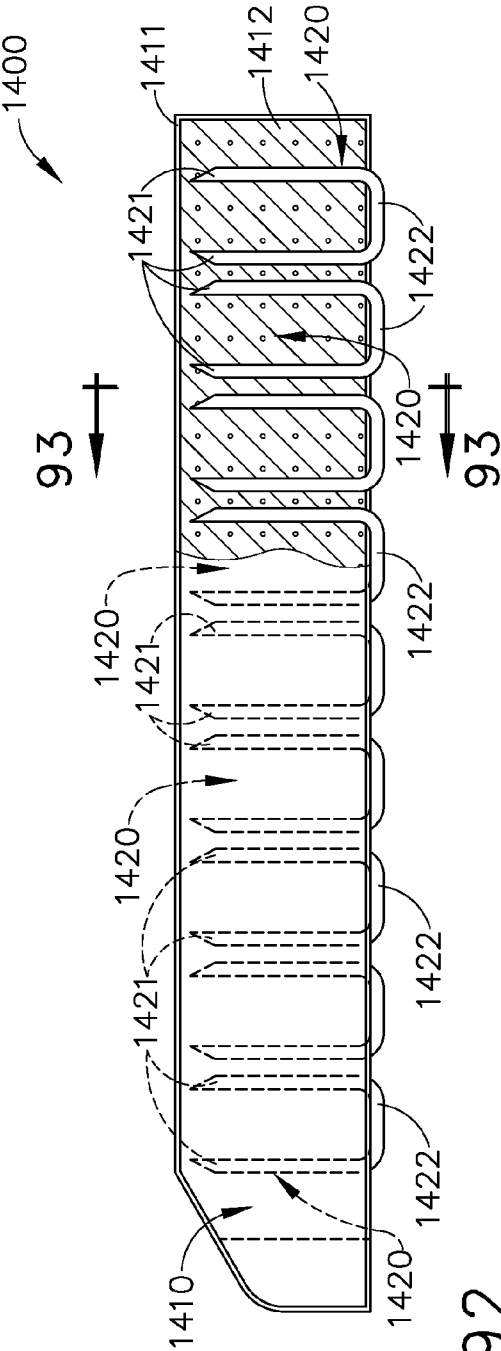


FIG. 92

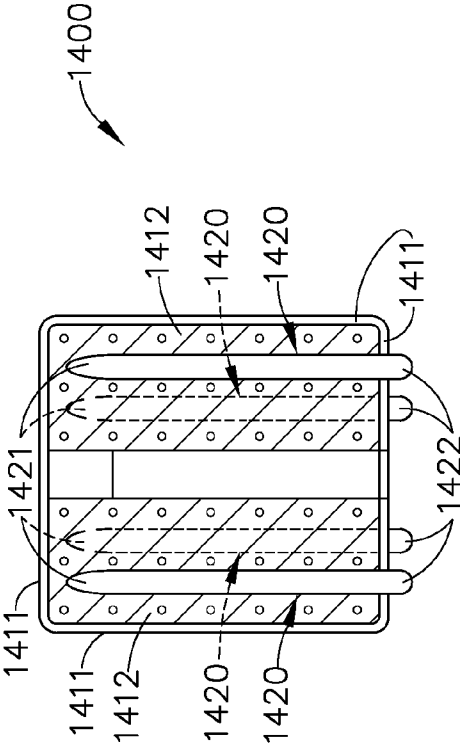


FIG. 93

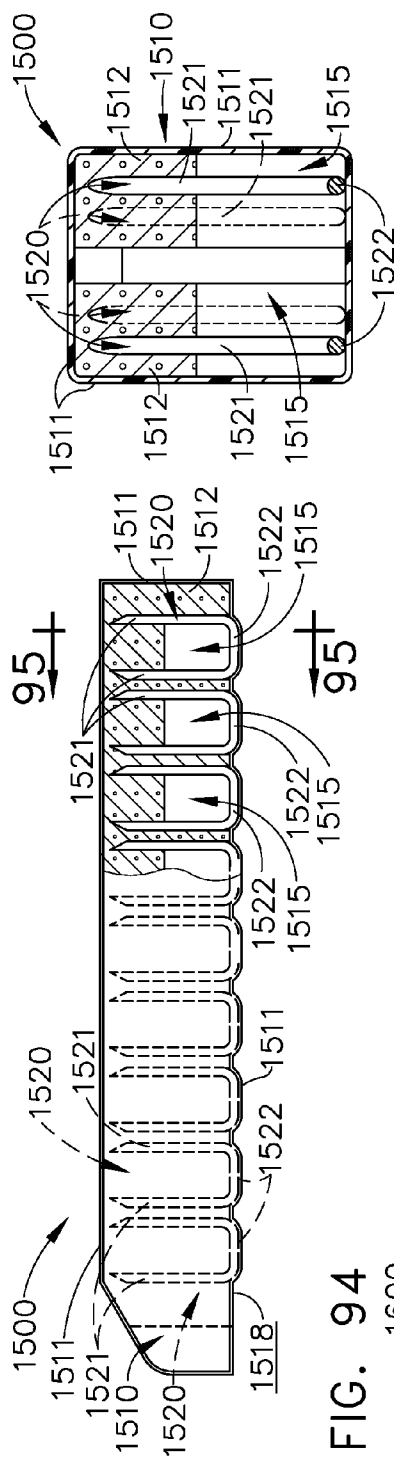


FIG. 95

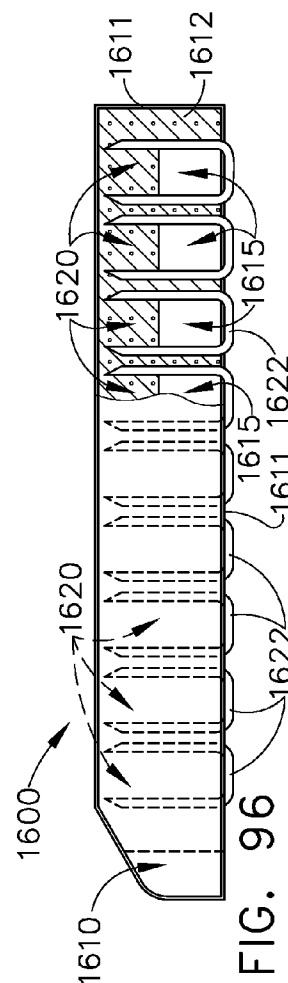


FIG. 96

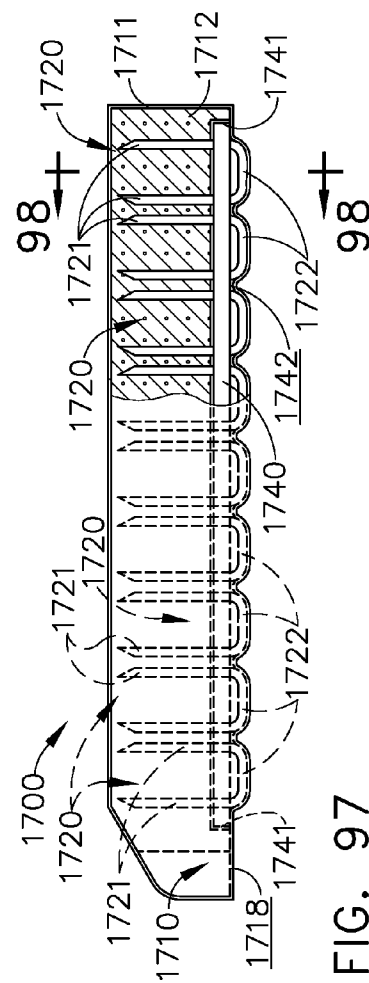


FIG. 97

FIG. 98

FIG. 99

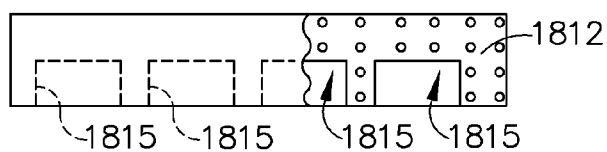


FIG. 100

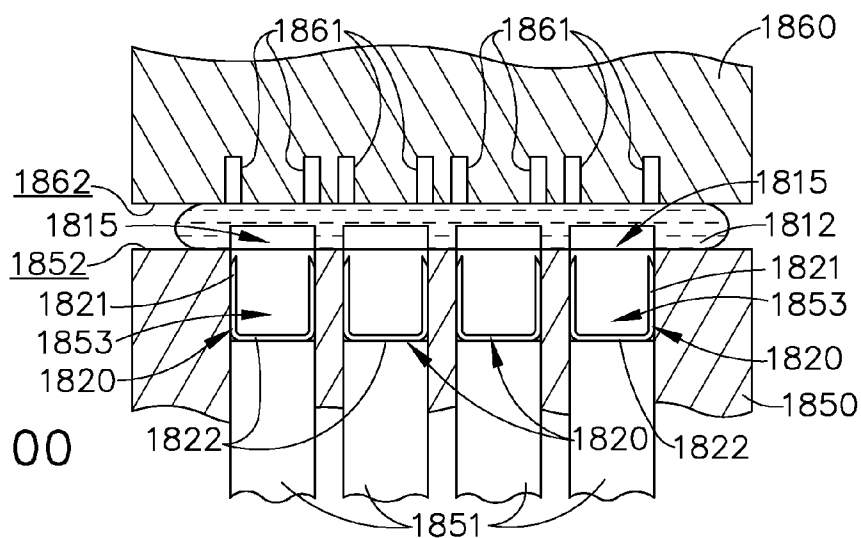
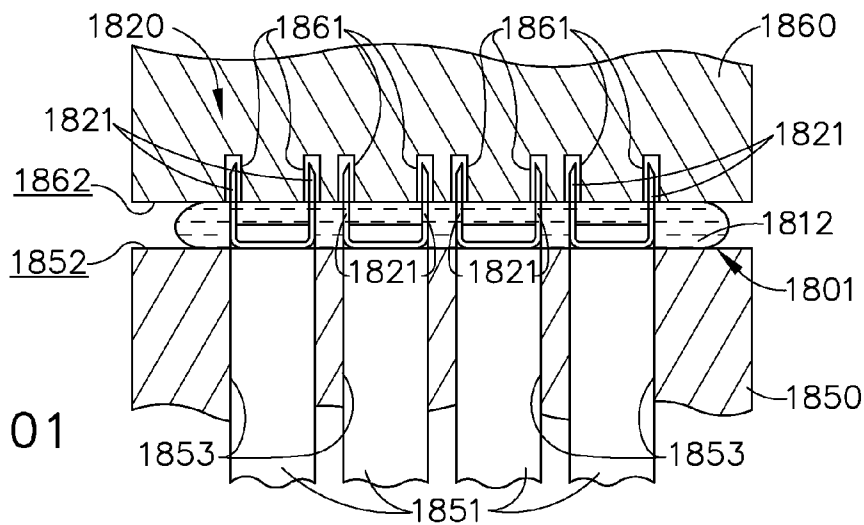


FIG. 101



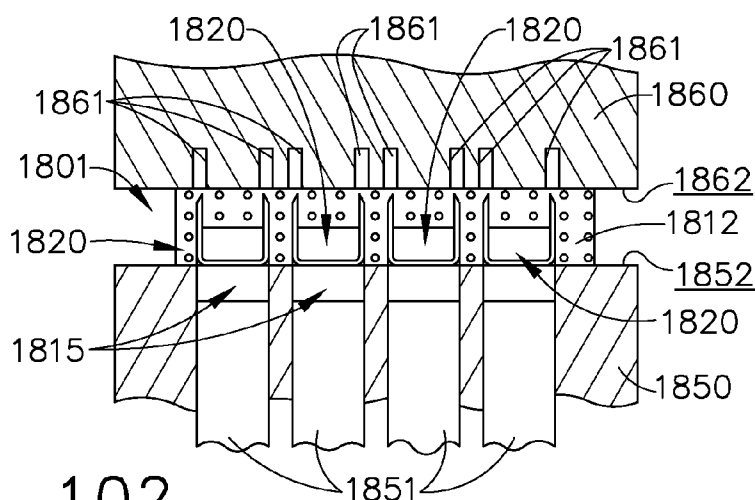


FIG. 102

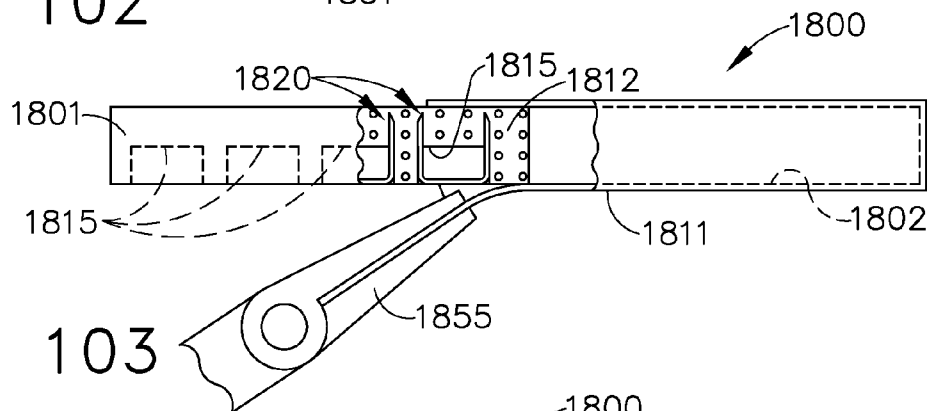


FIG. 103

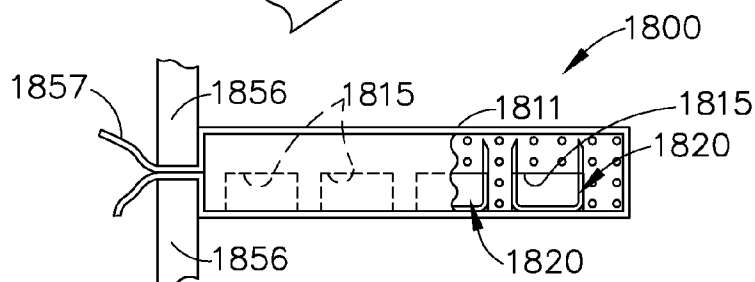


FIG. 104

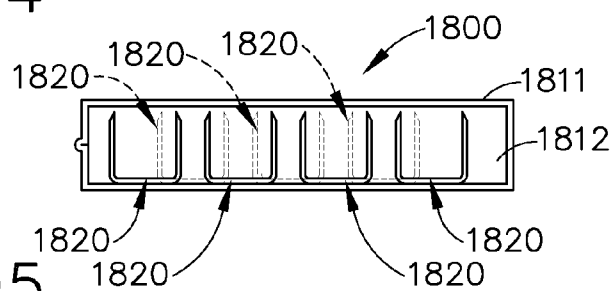


FIG. 105

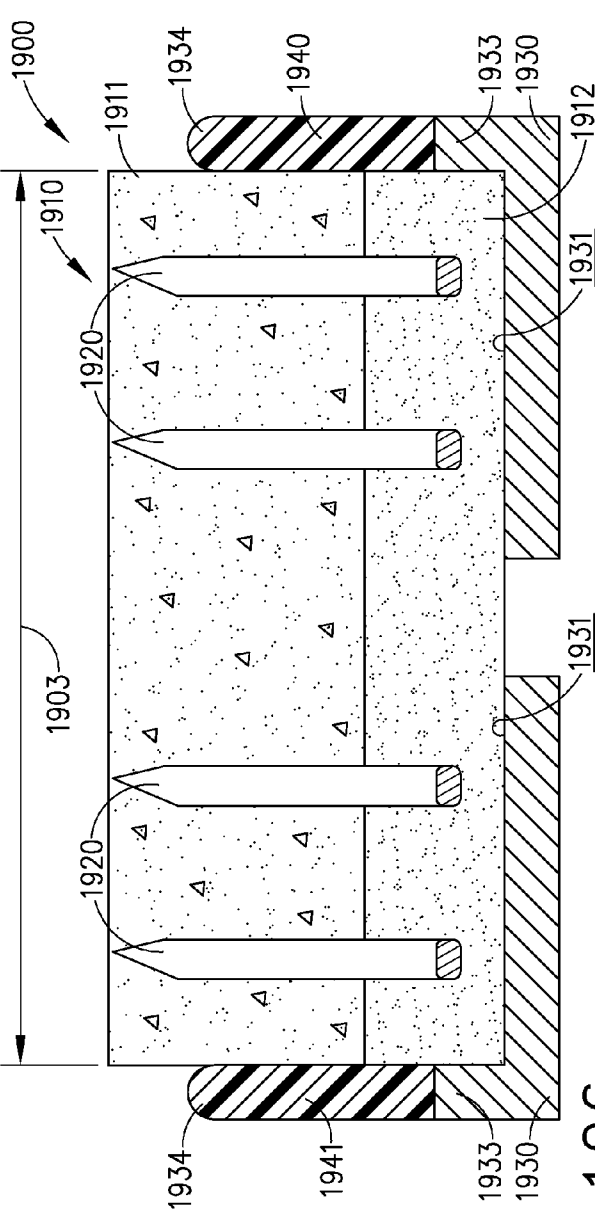


FIG. 106

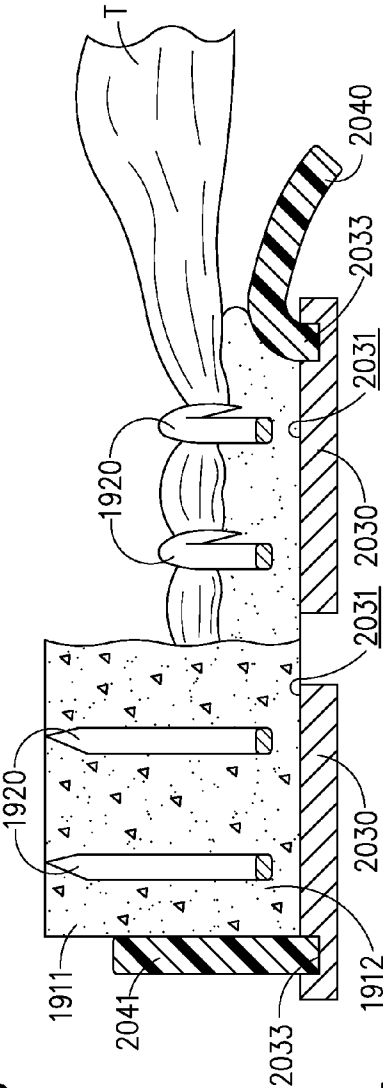


FIG. 107

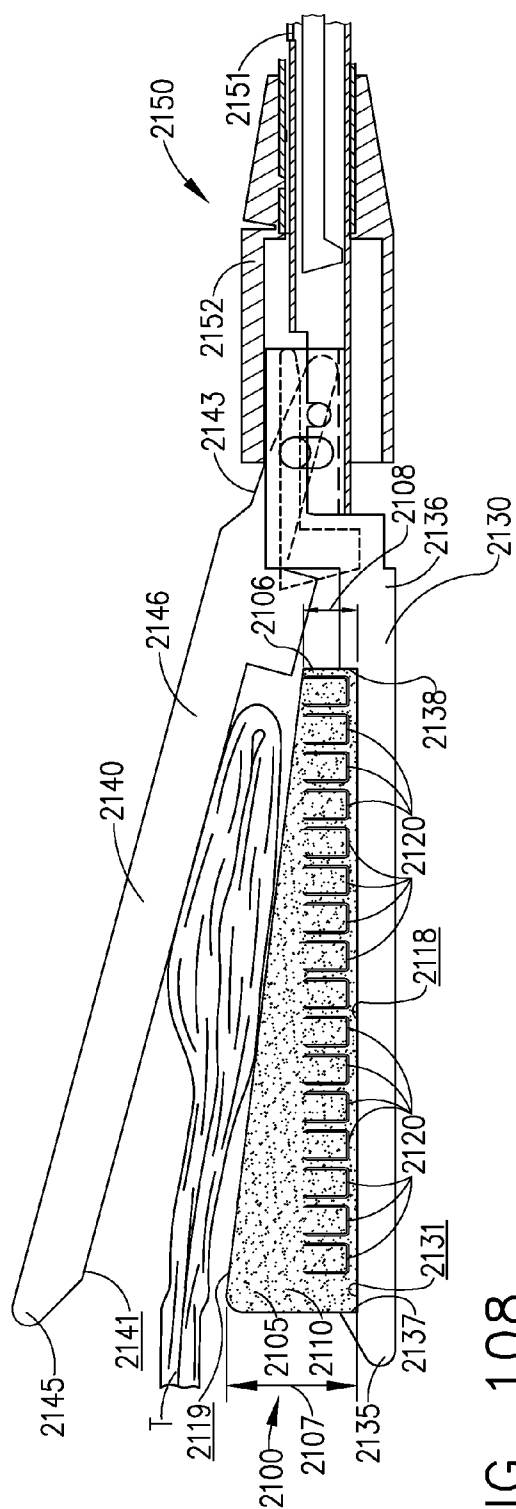


FIG. 108

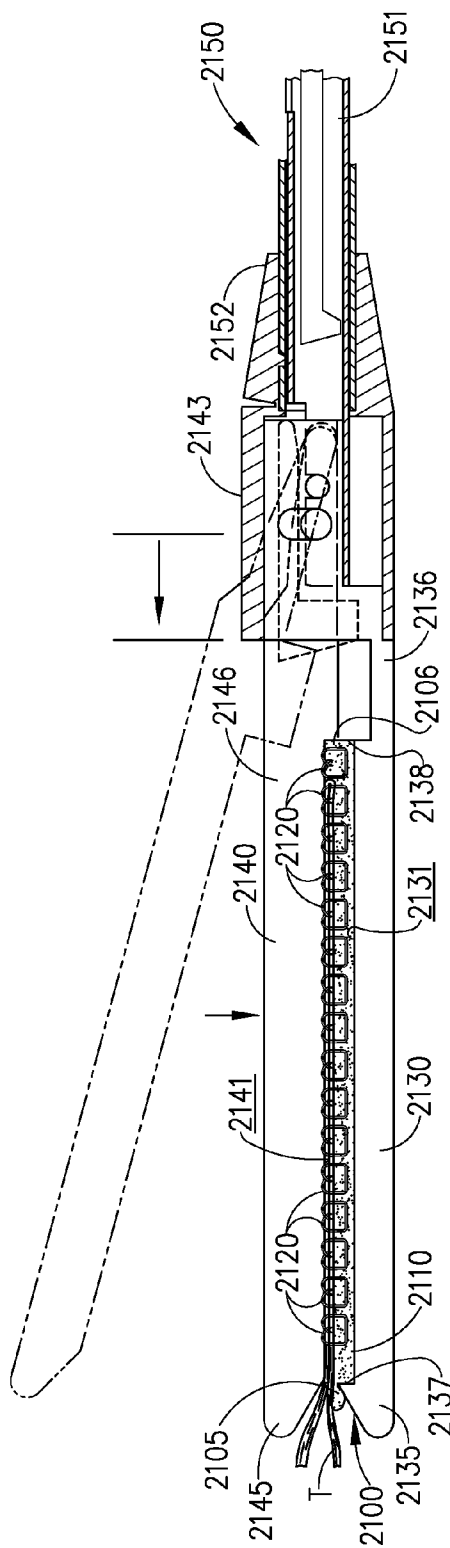


FIG. 109

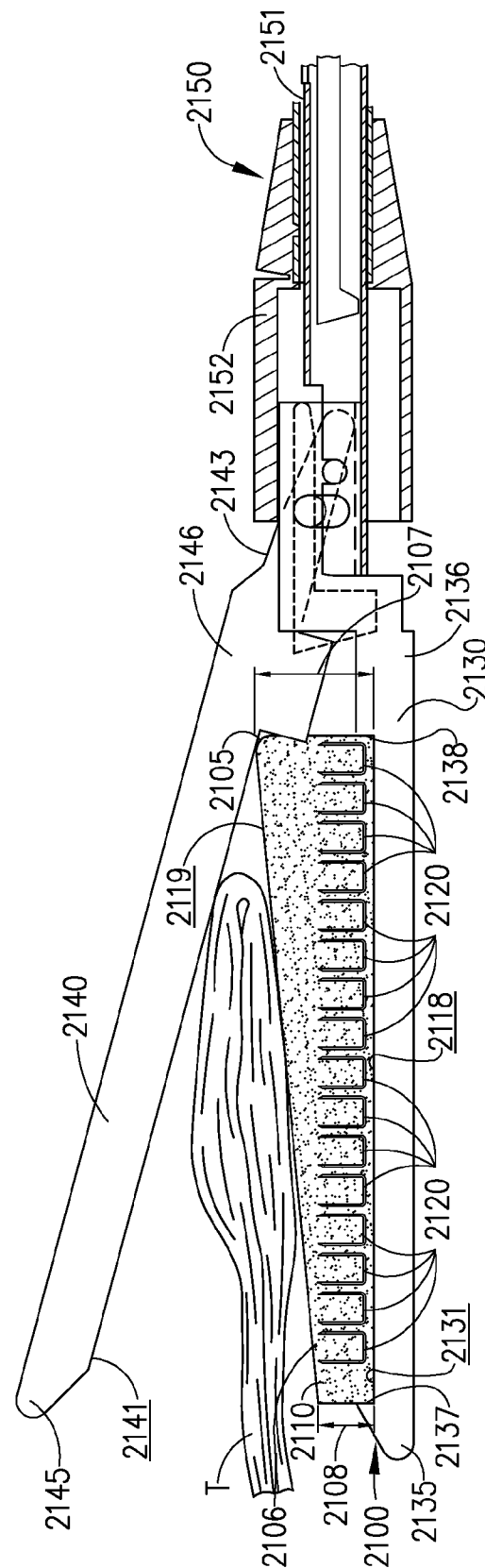


FIG. 110

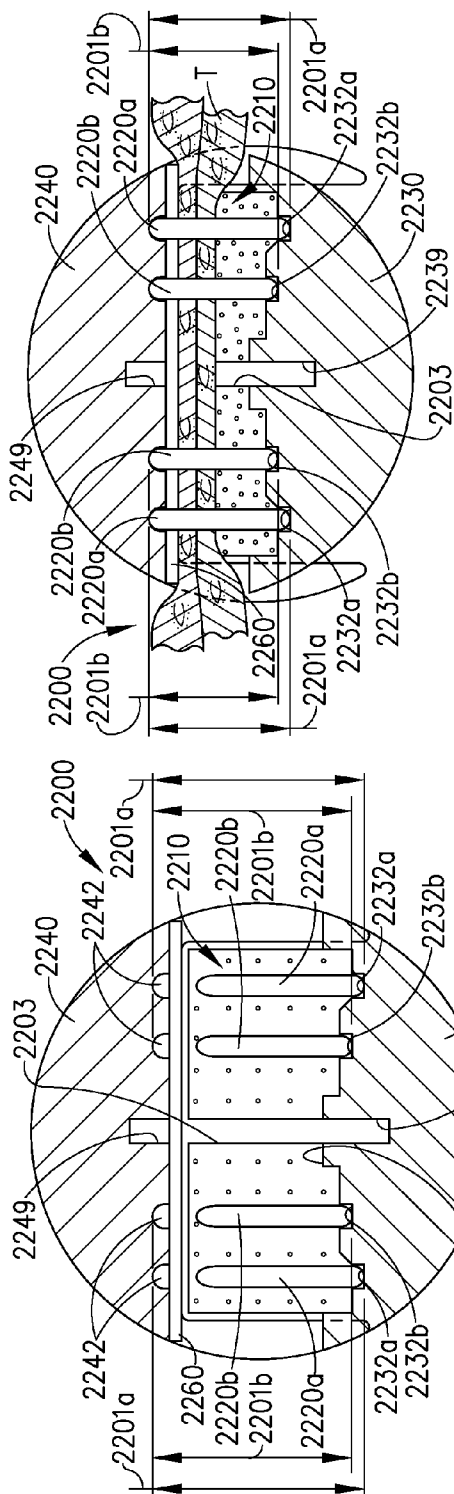


FIG. 111

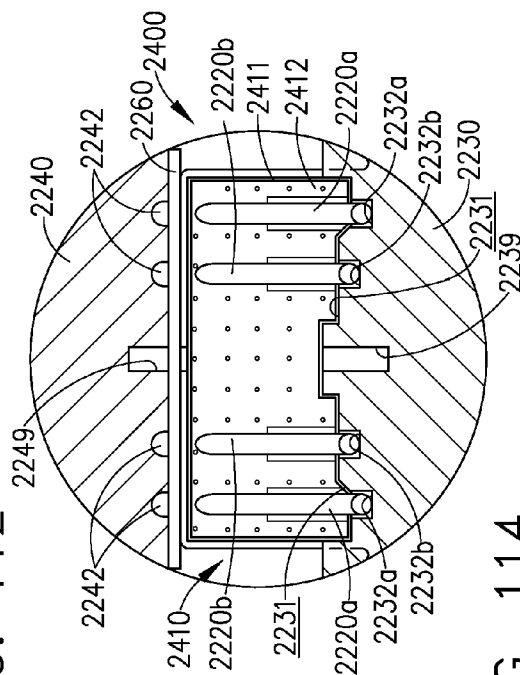


FIG. 112

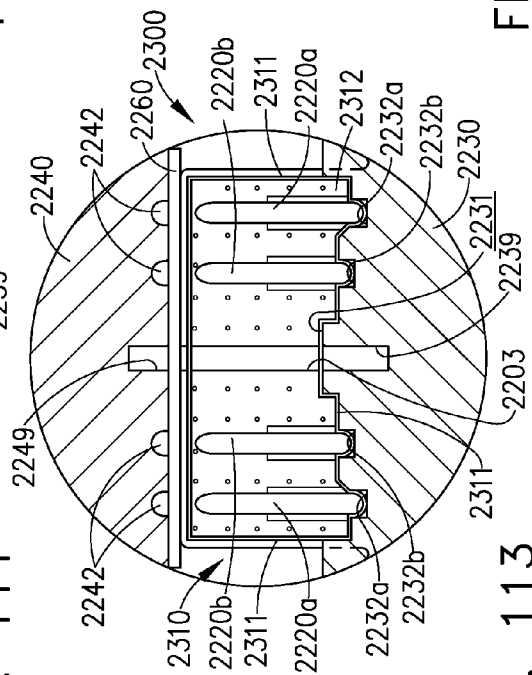
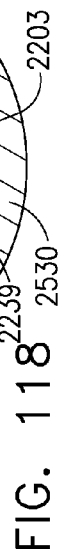
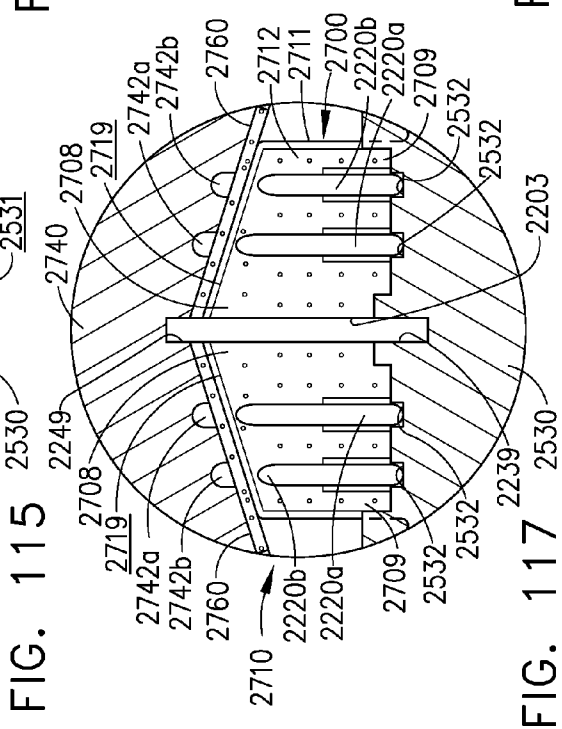
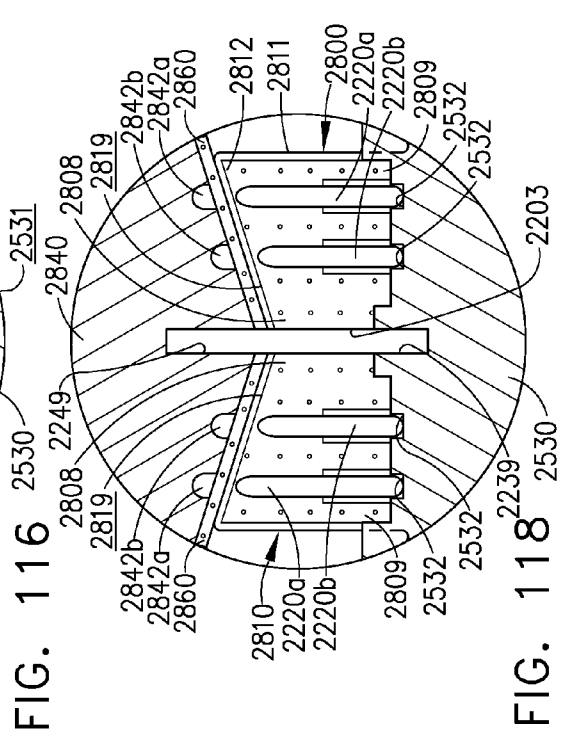
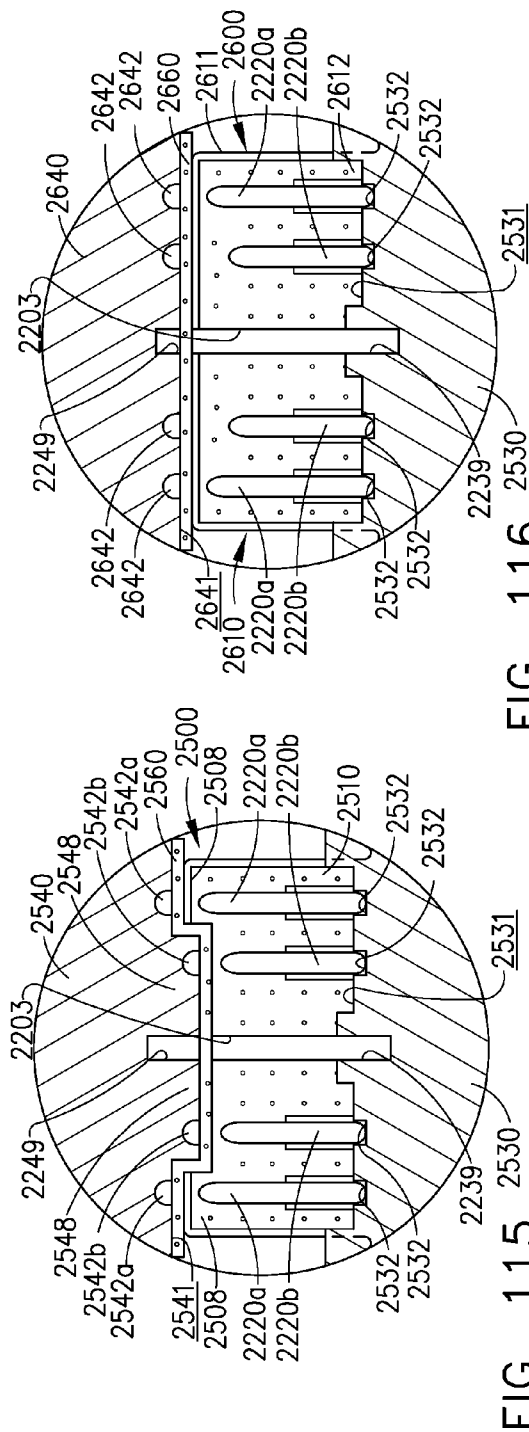


FIG. 113



FIG. 114



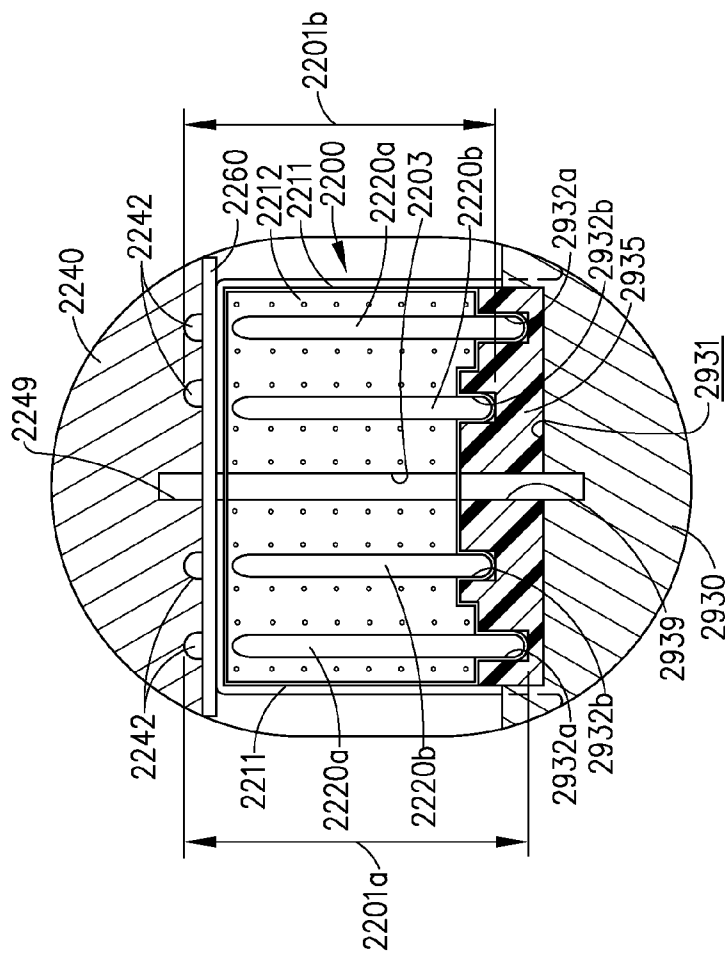


FIG. 119

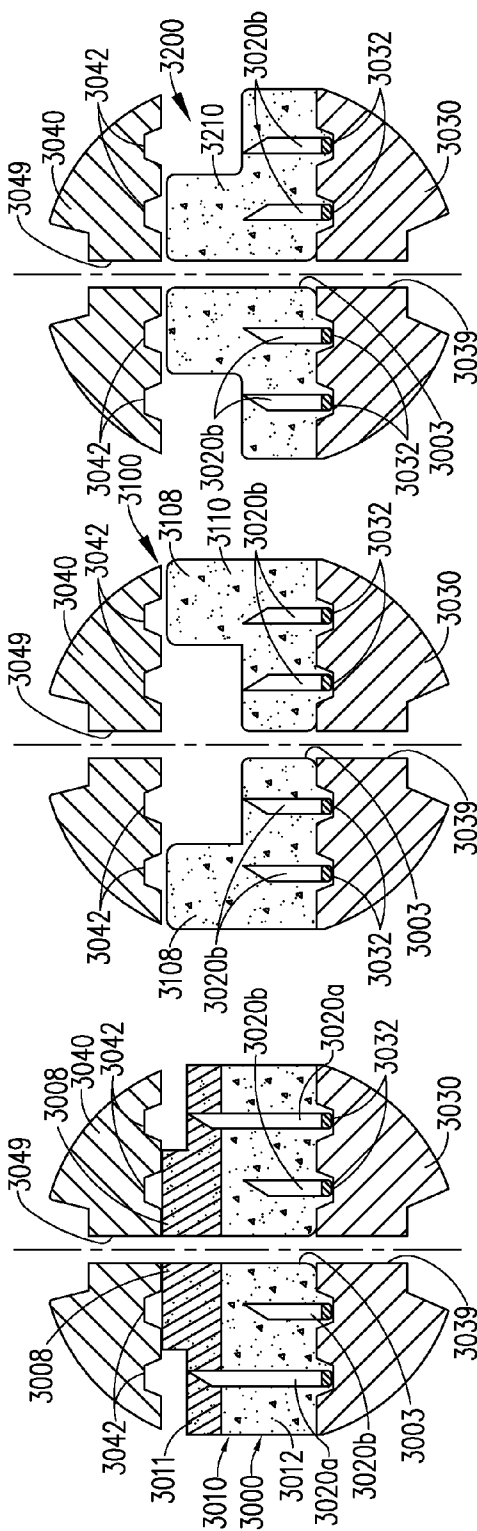


FIG. 120

FIG. 121

FIG. 122

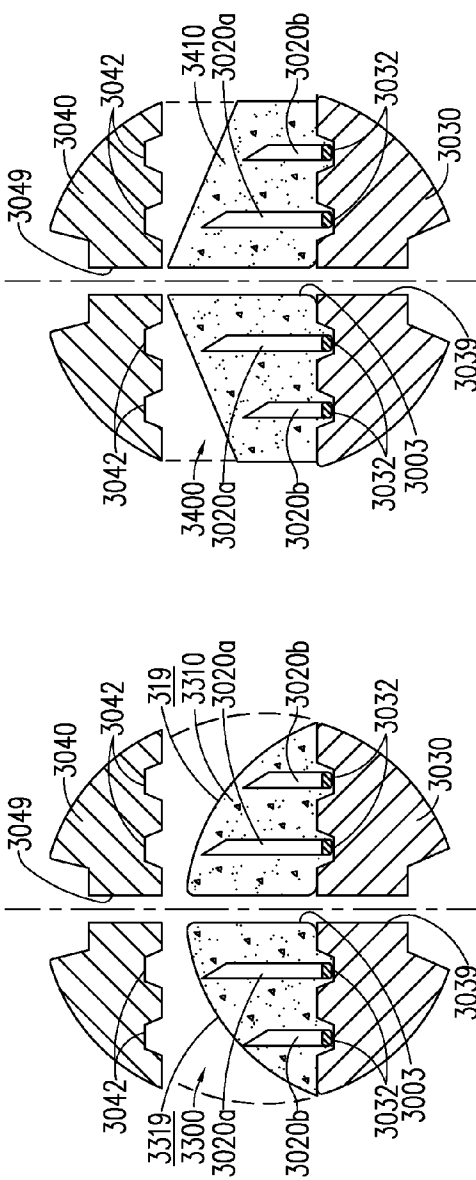


FIG. 123

FIG. 124

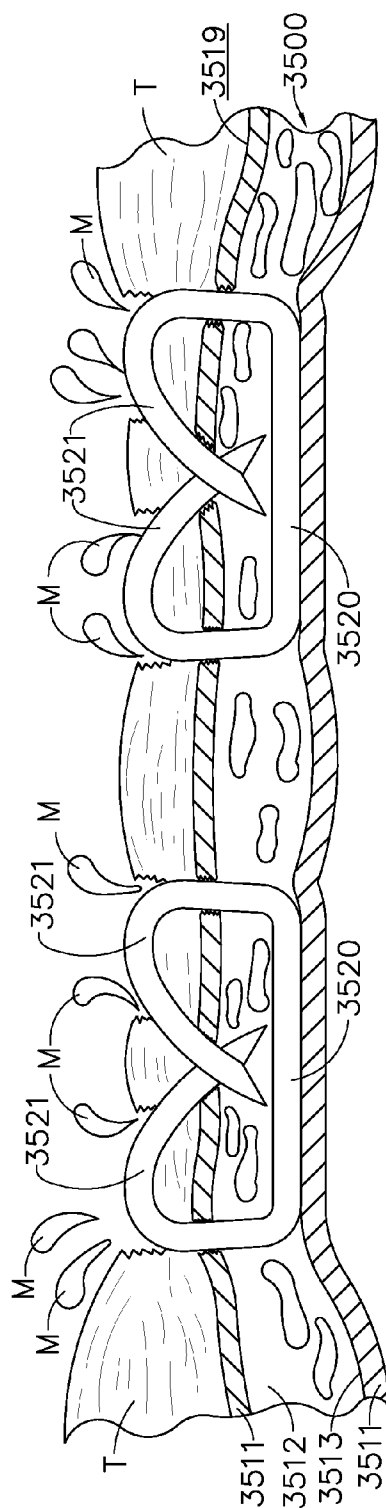
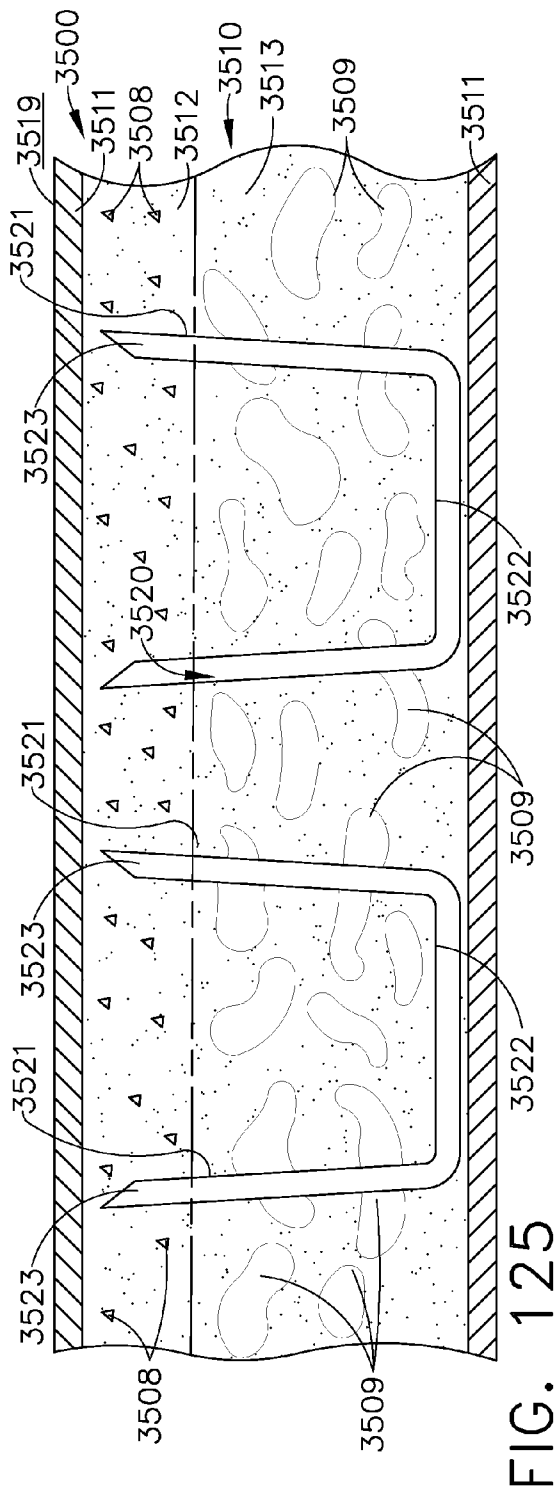
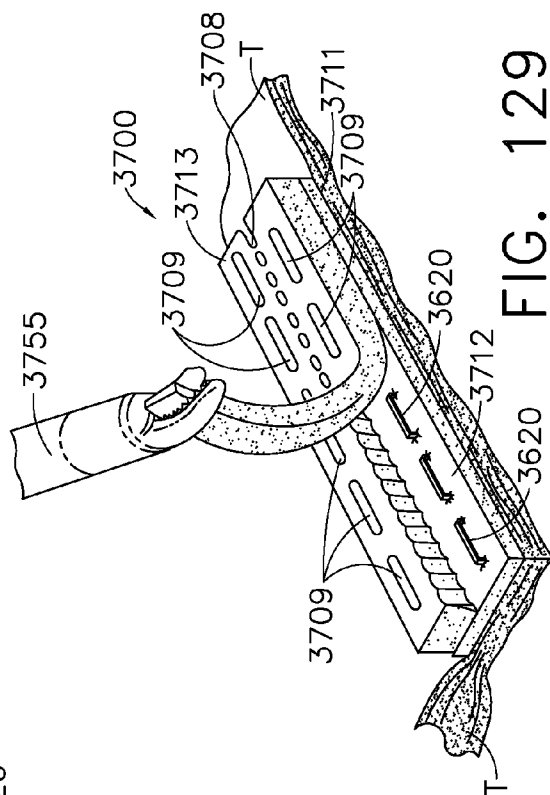
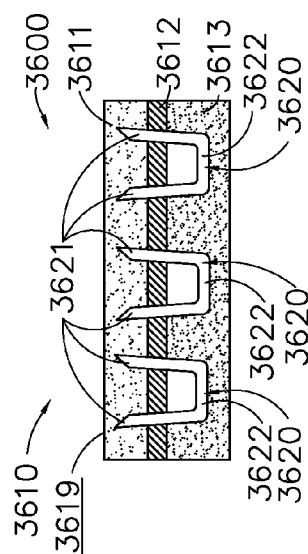
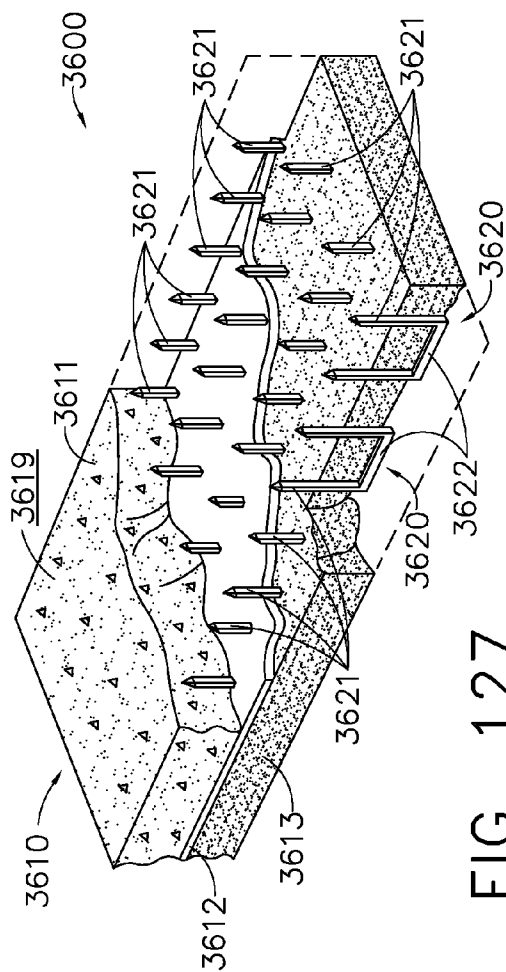


FIG. 126



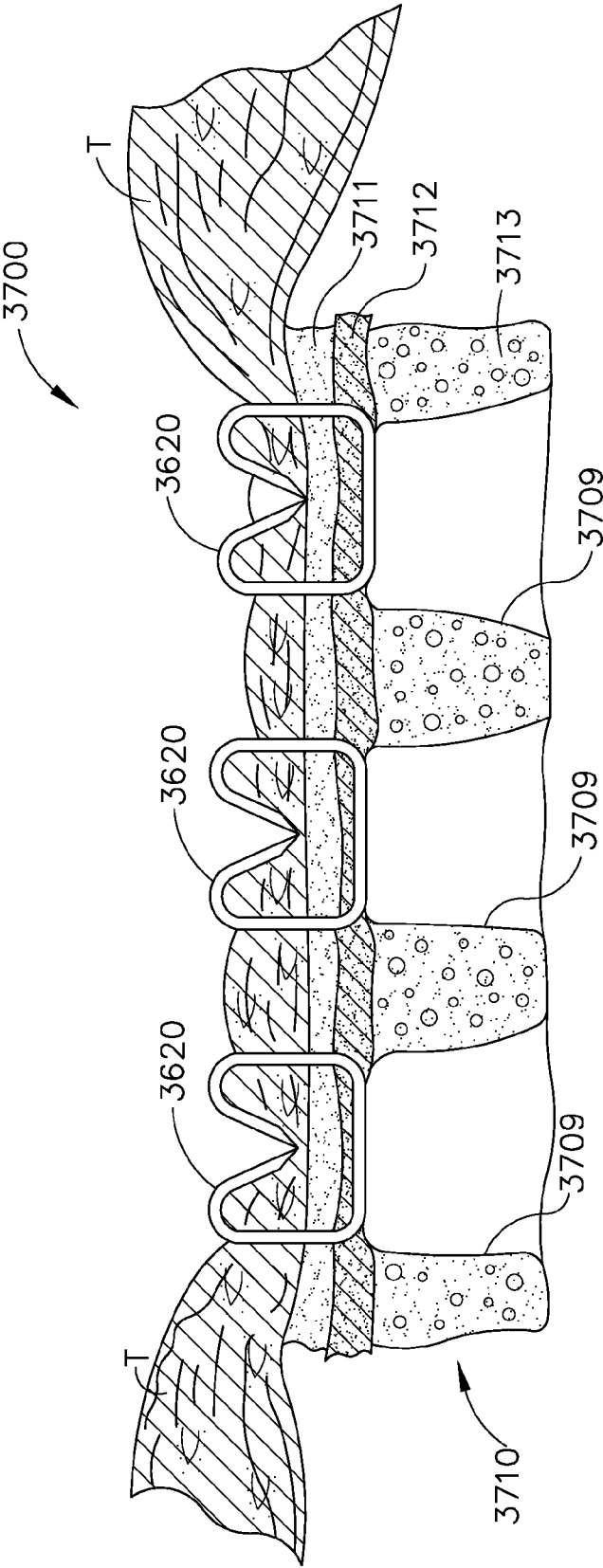


FIG. 130

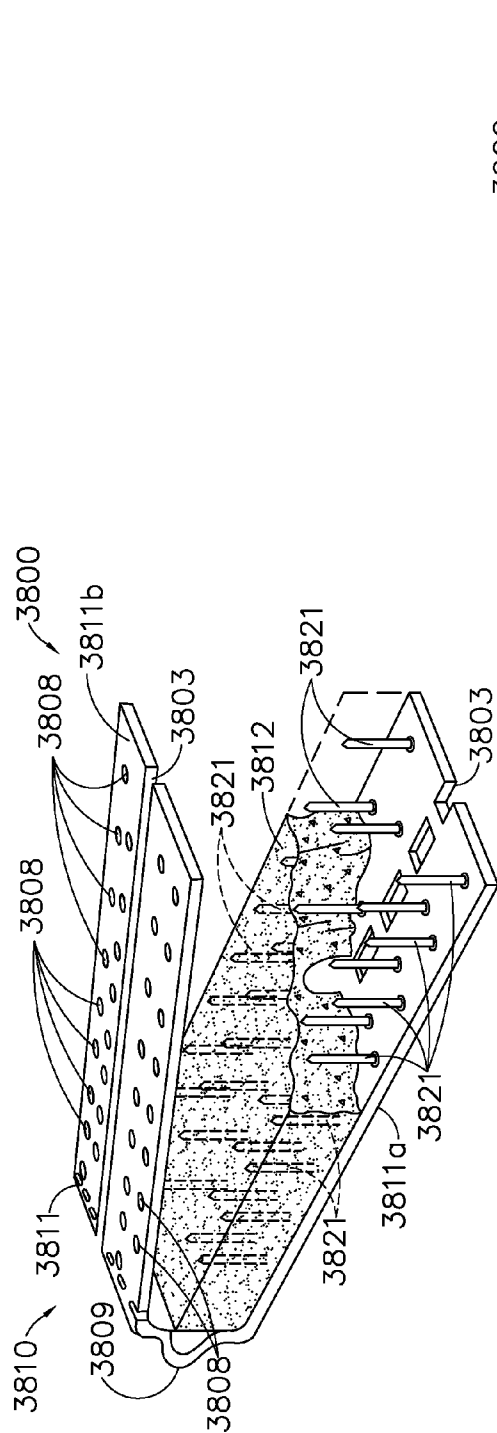


FIG. 131

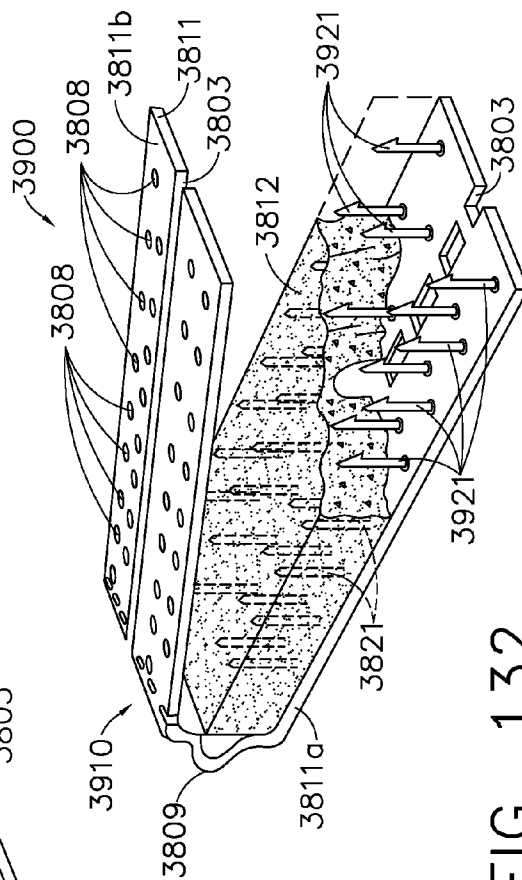
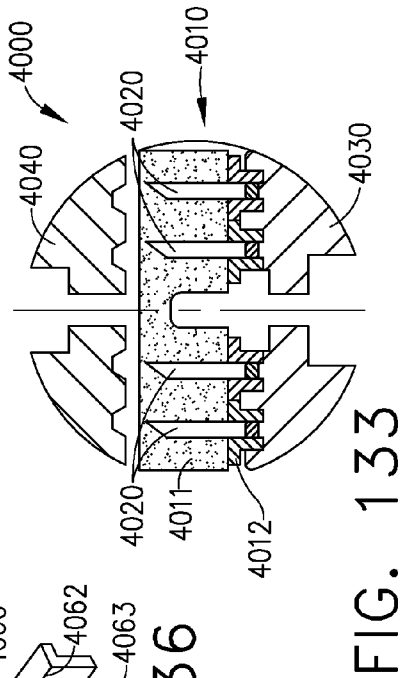
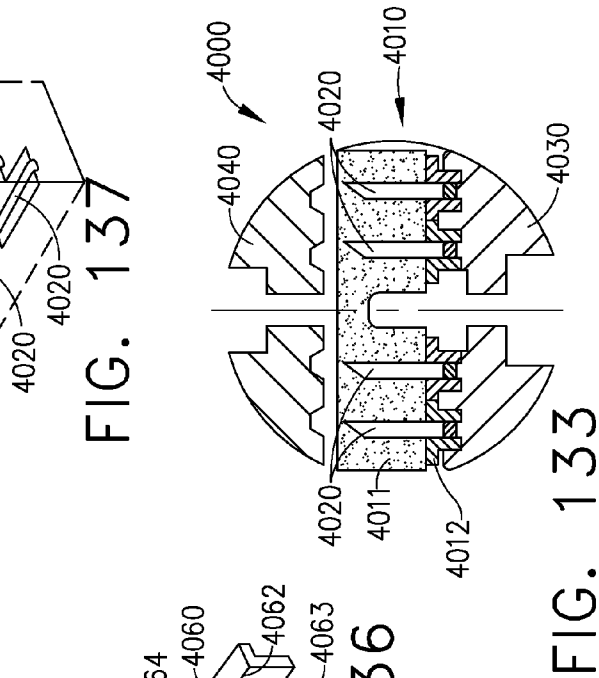
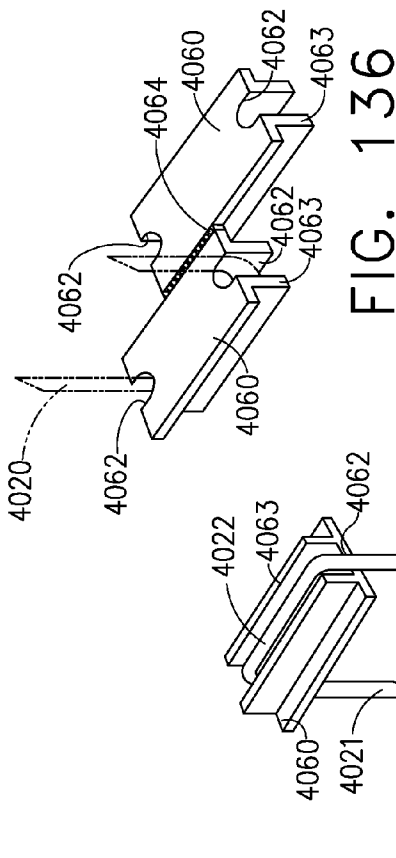
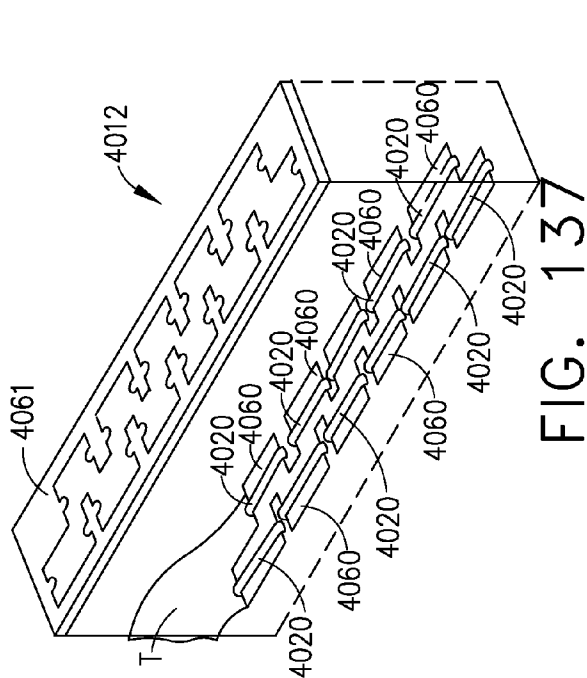
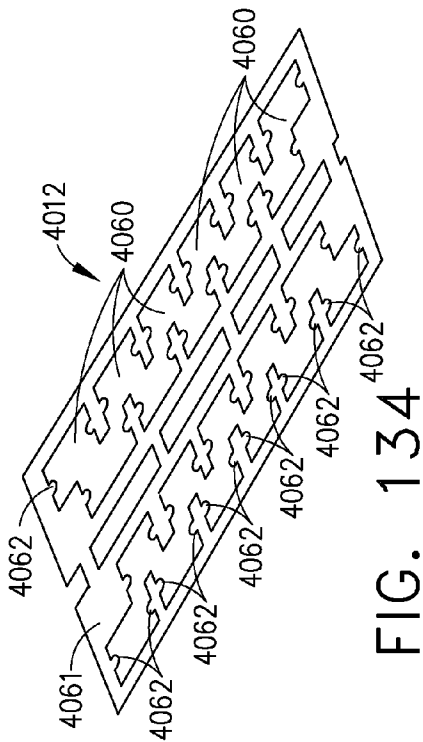


FIG. 132



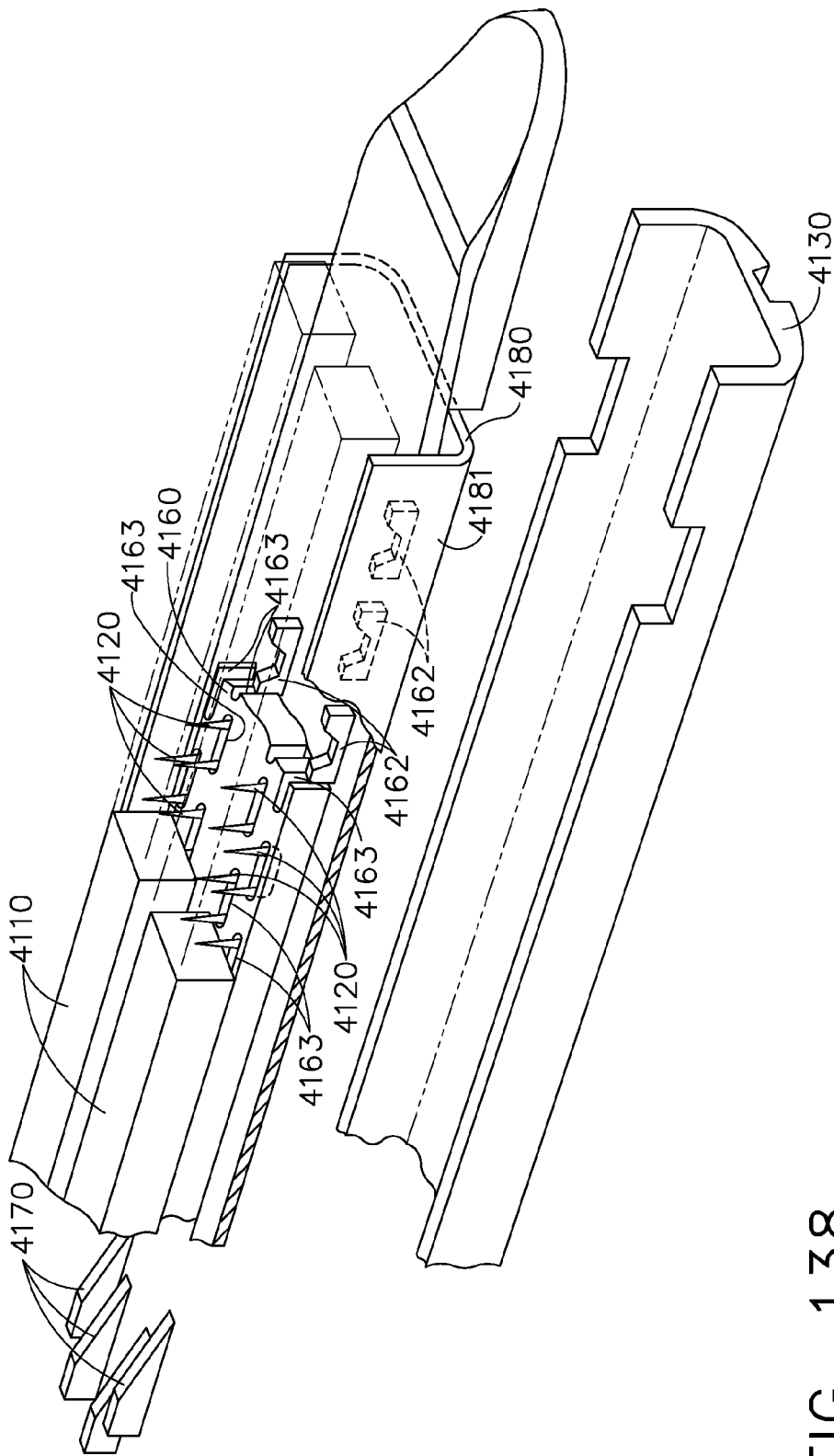


FIG. 138

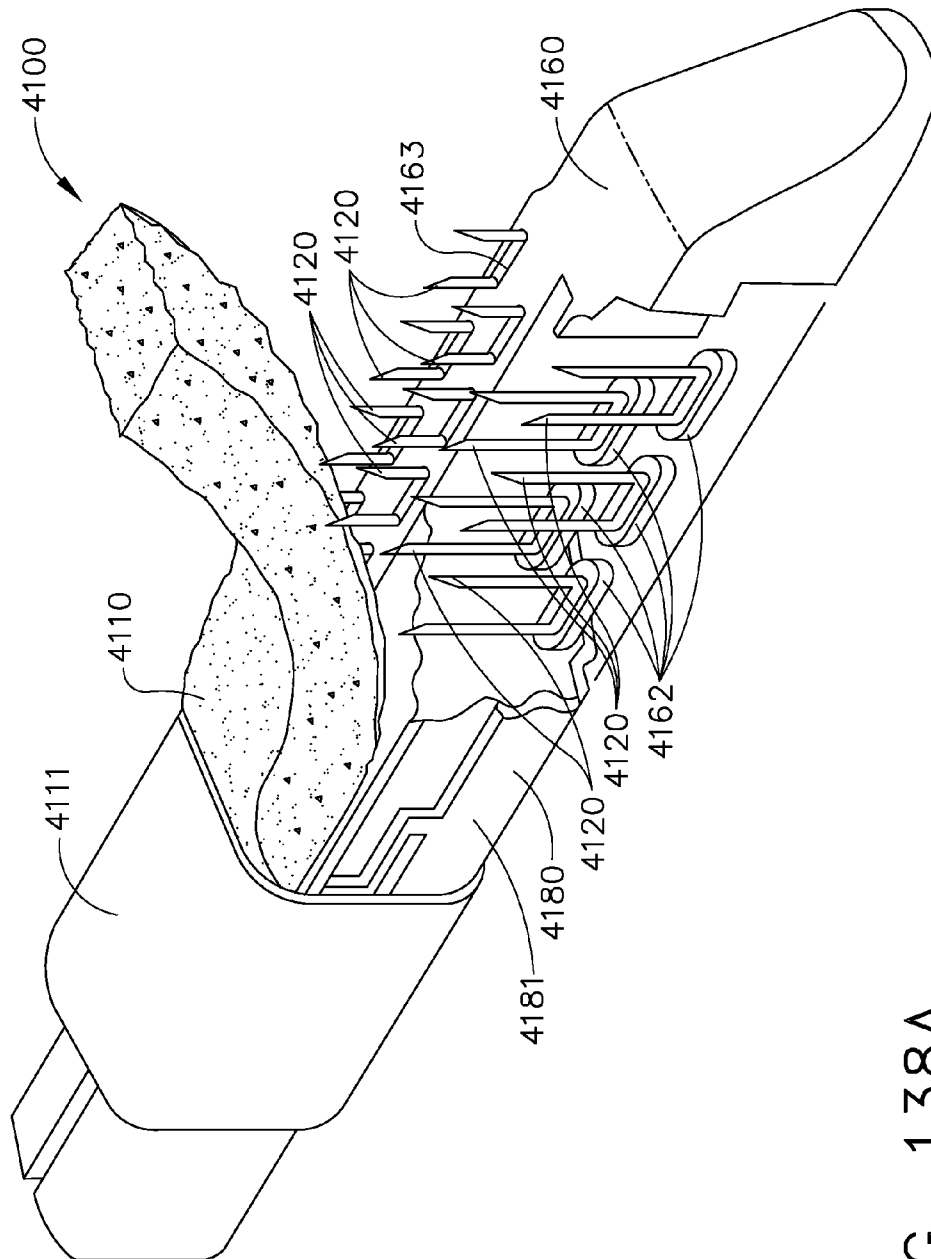


FIG. 138A

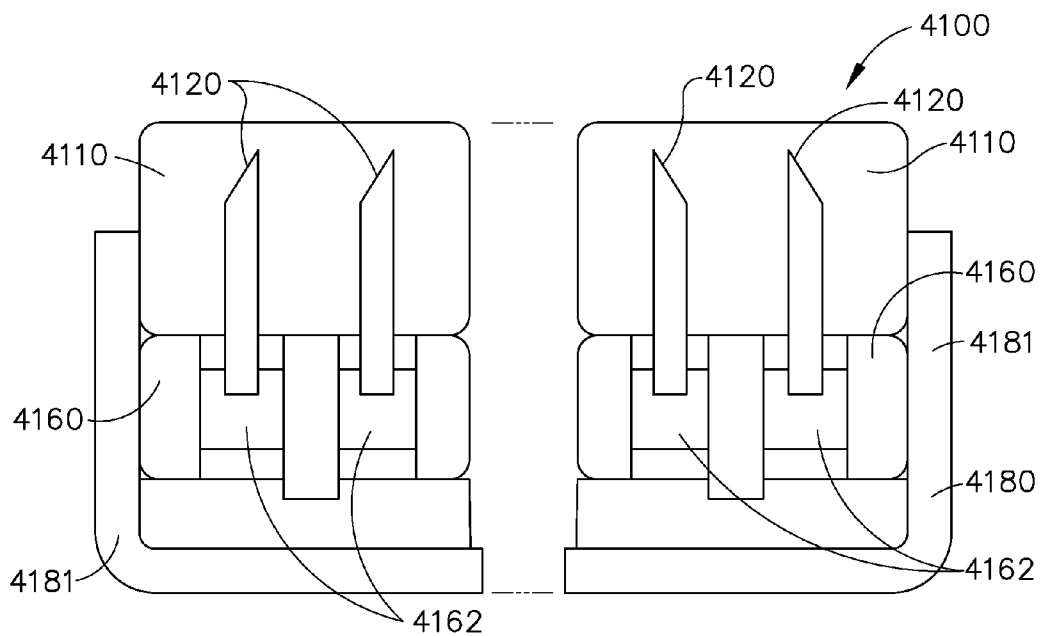


FIG. 139



FIG. 140

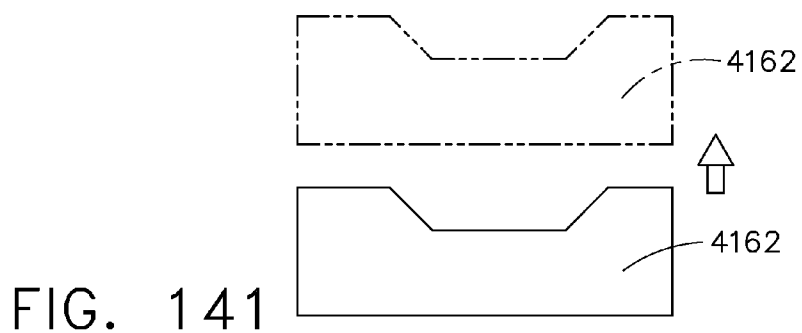


FIG. 141

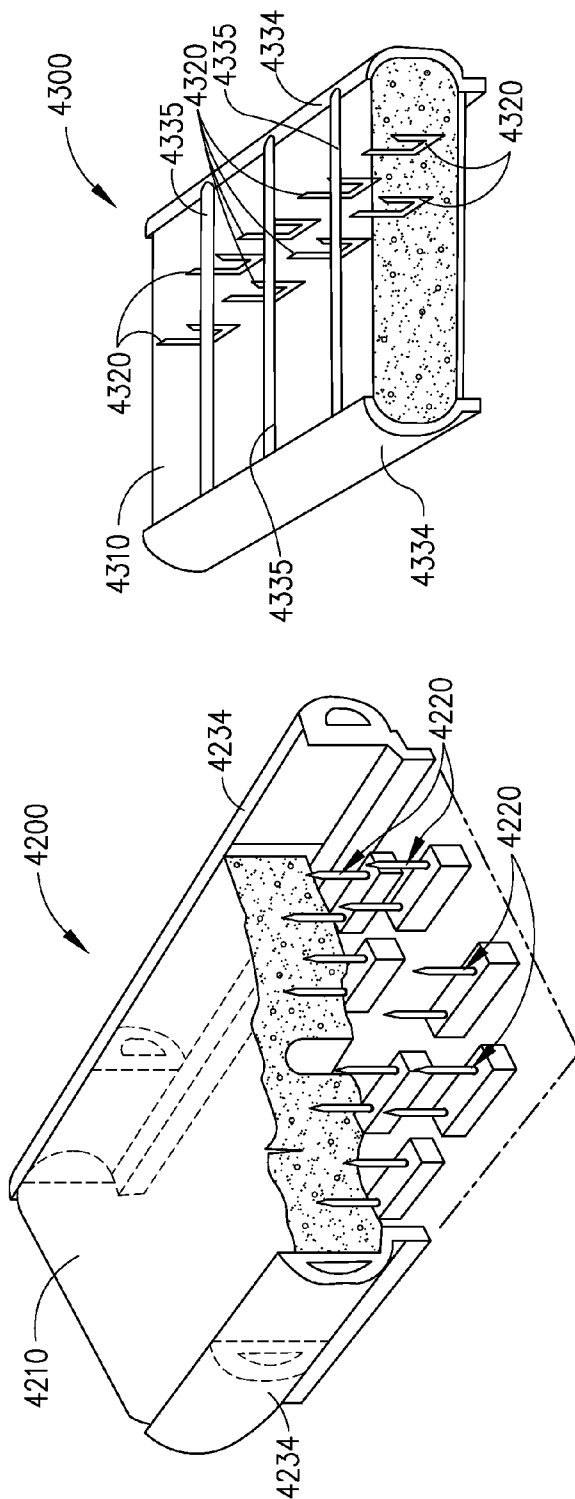


FIG. 142

FIG. 146

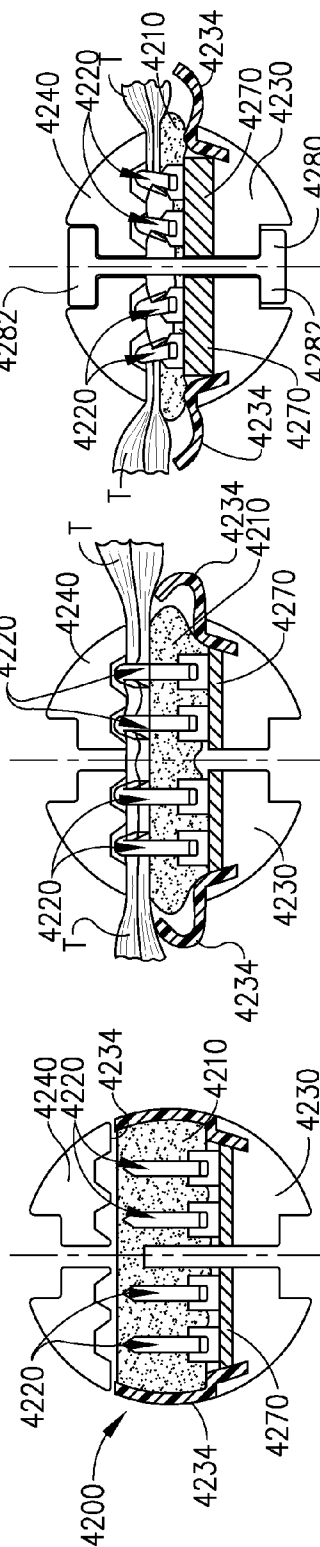


FIG. 143

FIG. 144

FIG. 145

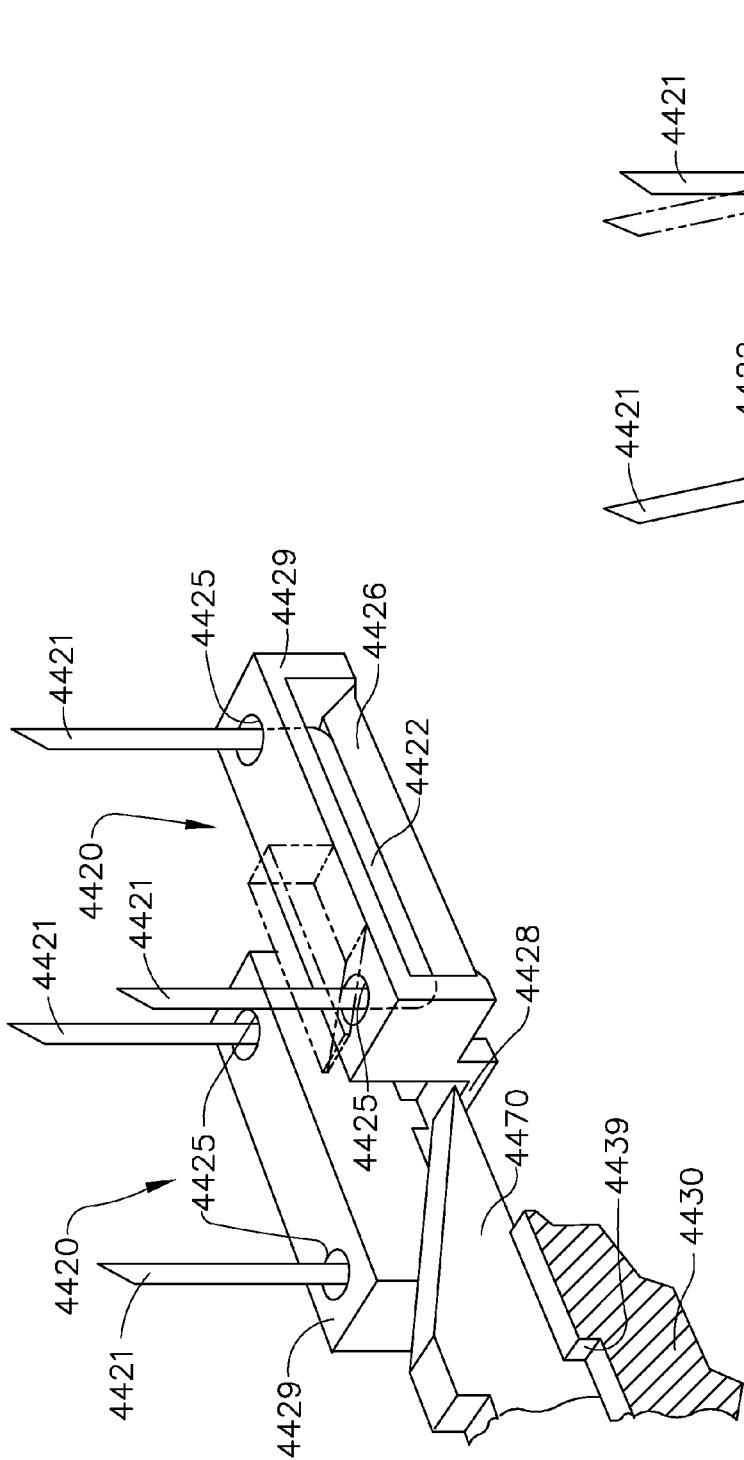


FIG. 149

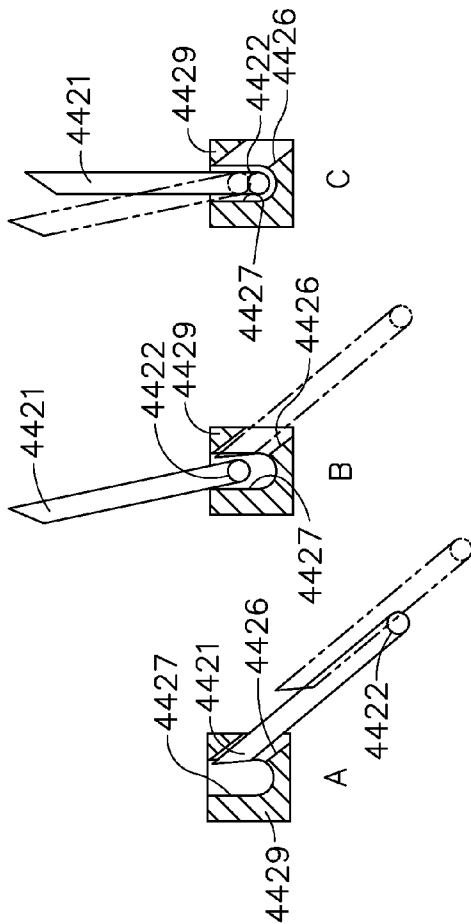


FIG. 150

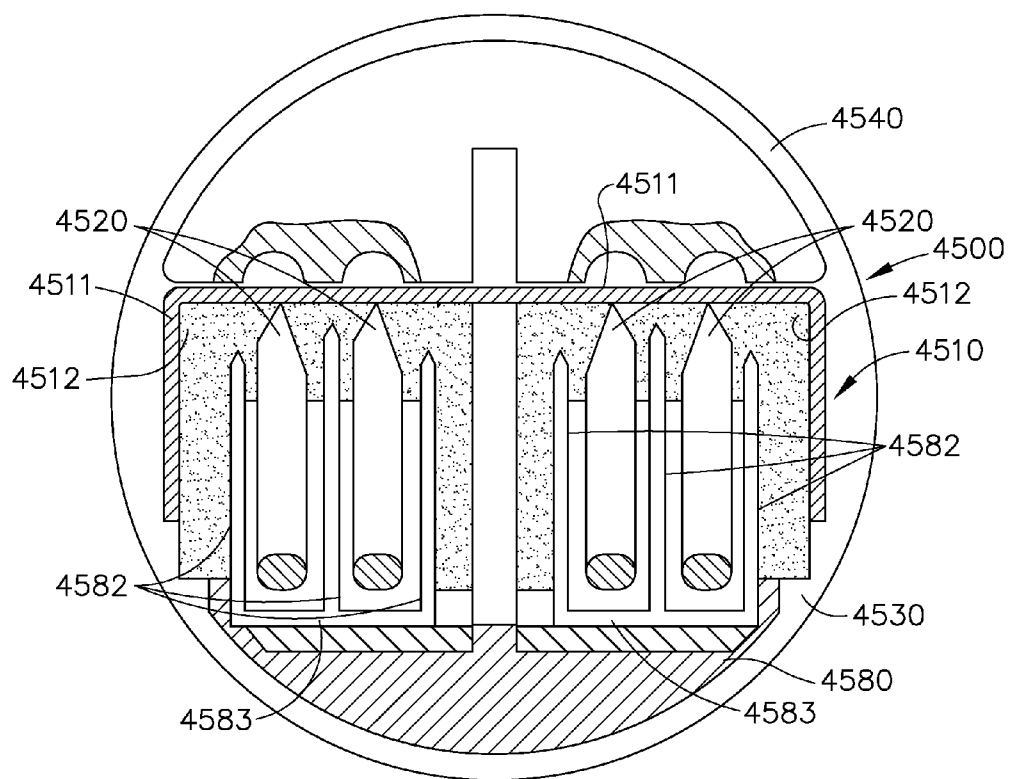


FIG. 151

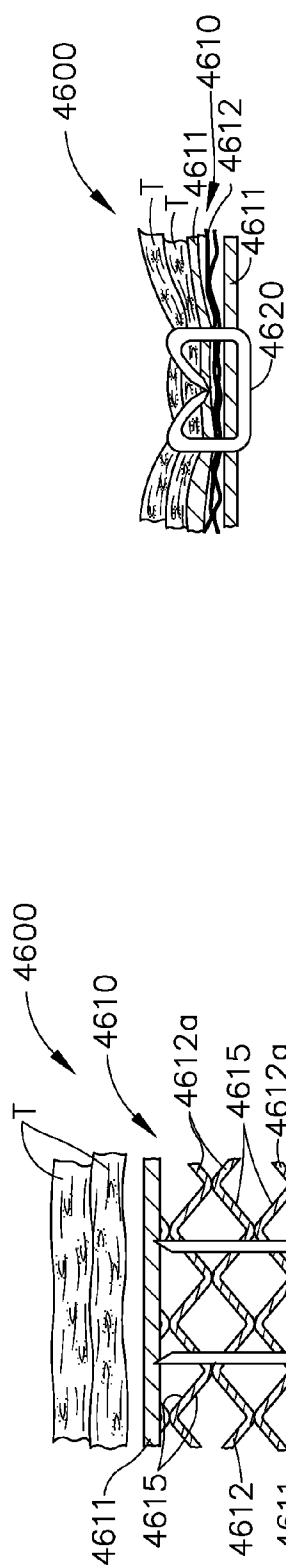


FIG. 153

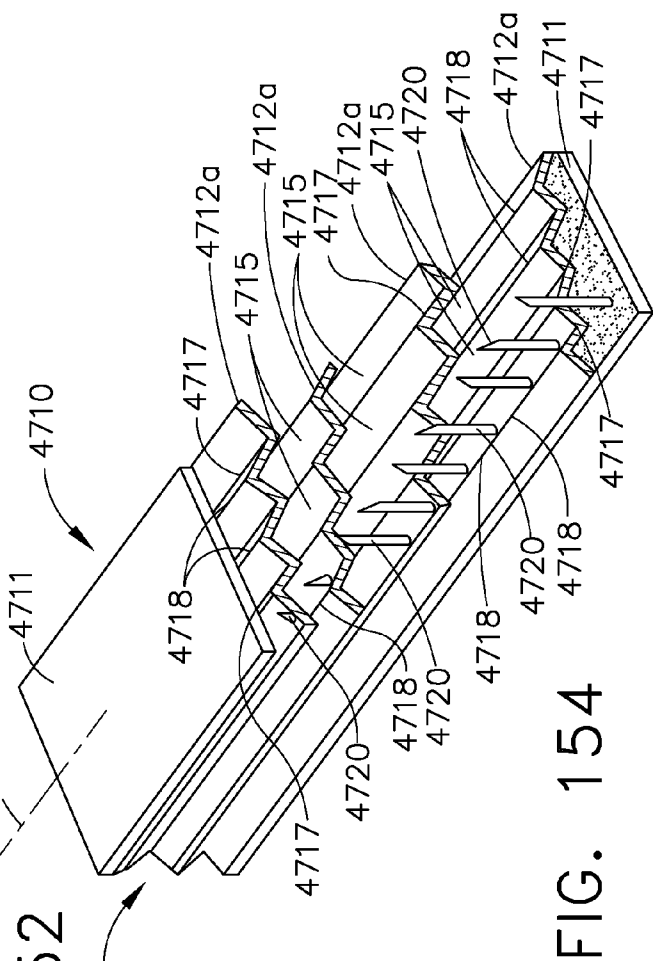
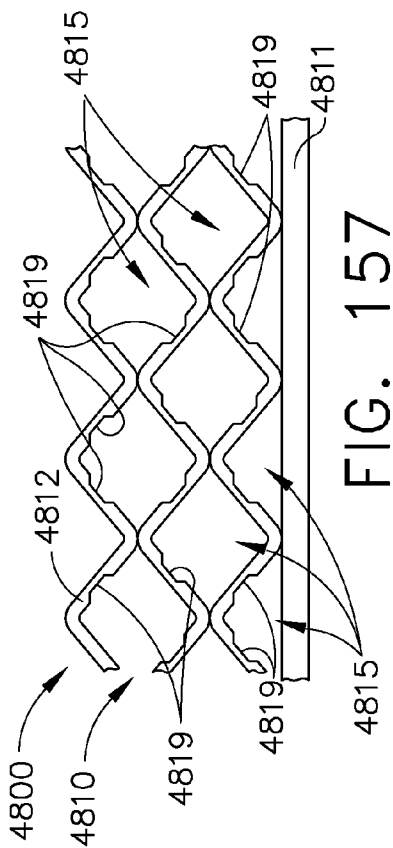
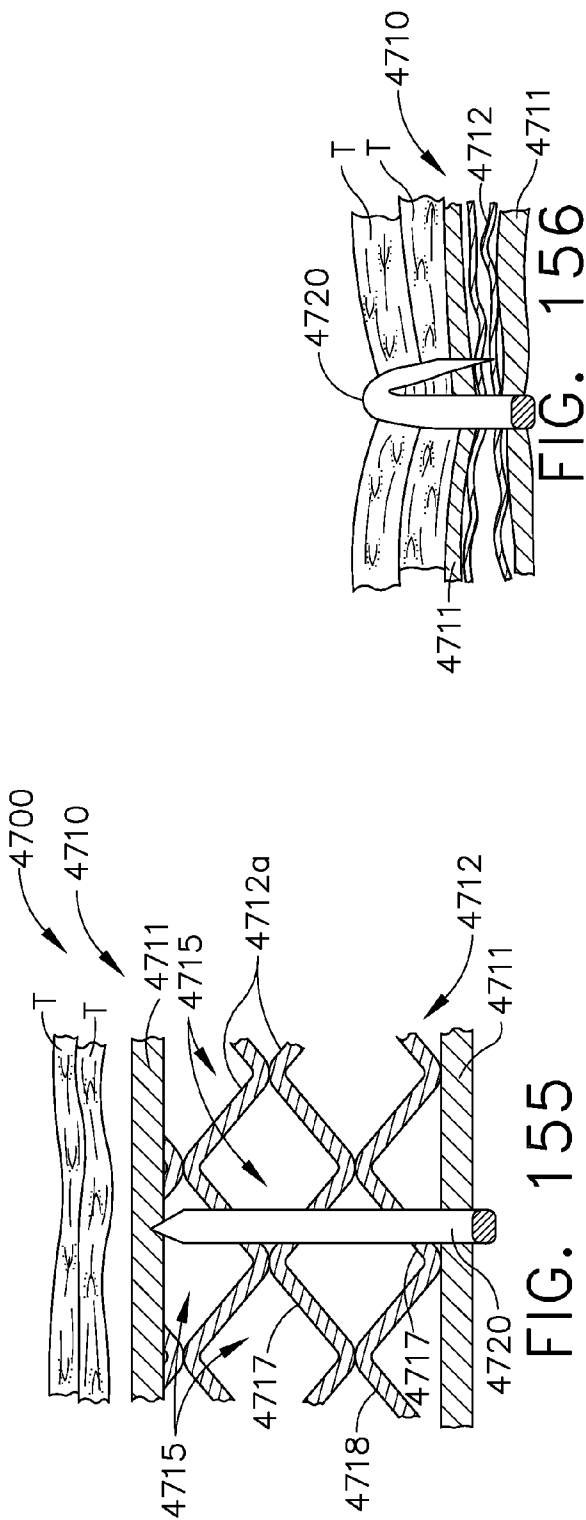


FIG. 152

FIG. 154



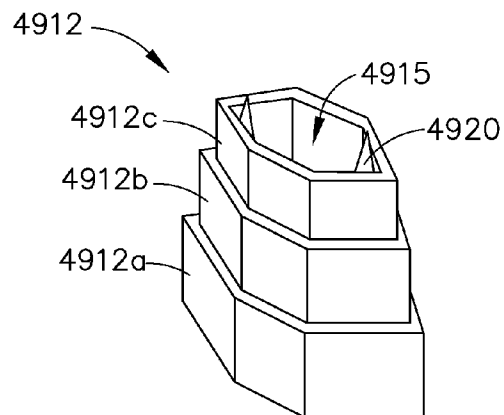


FIG. 159

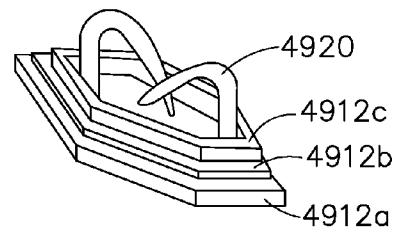


FIG. 160

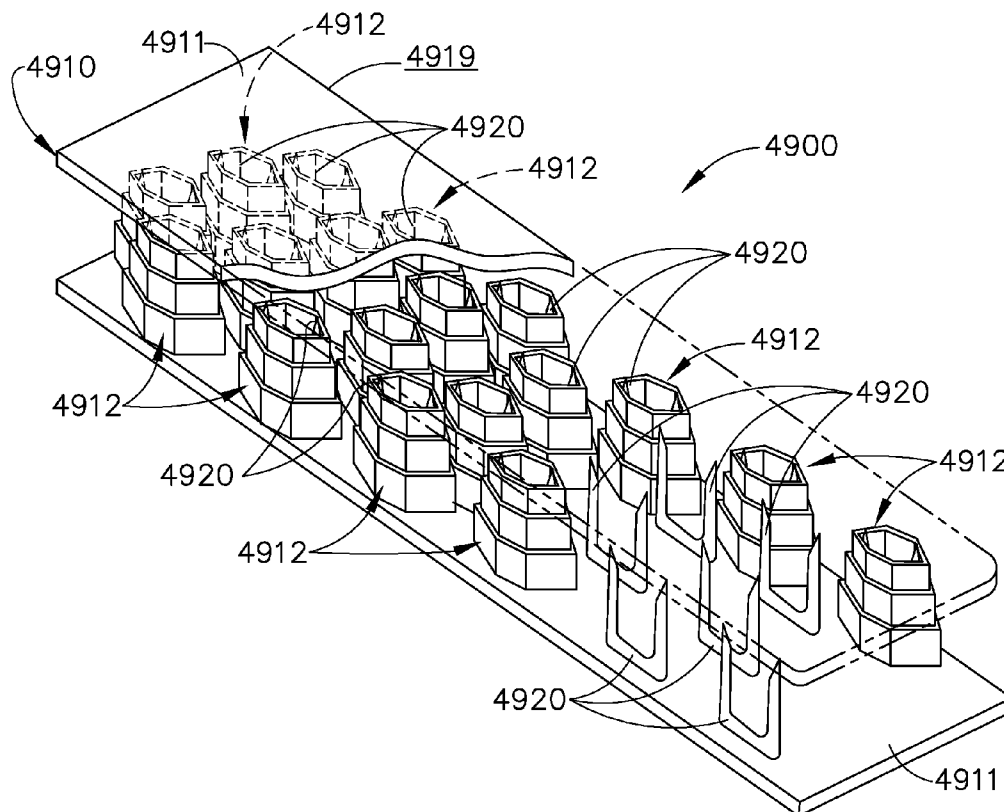


FIG. 158

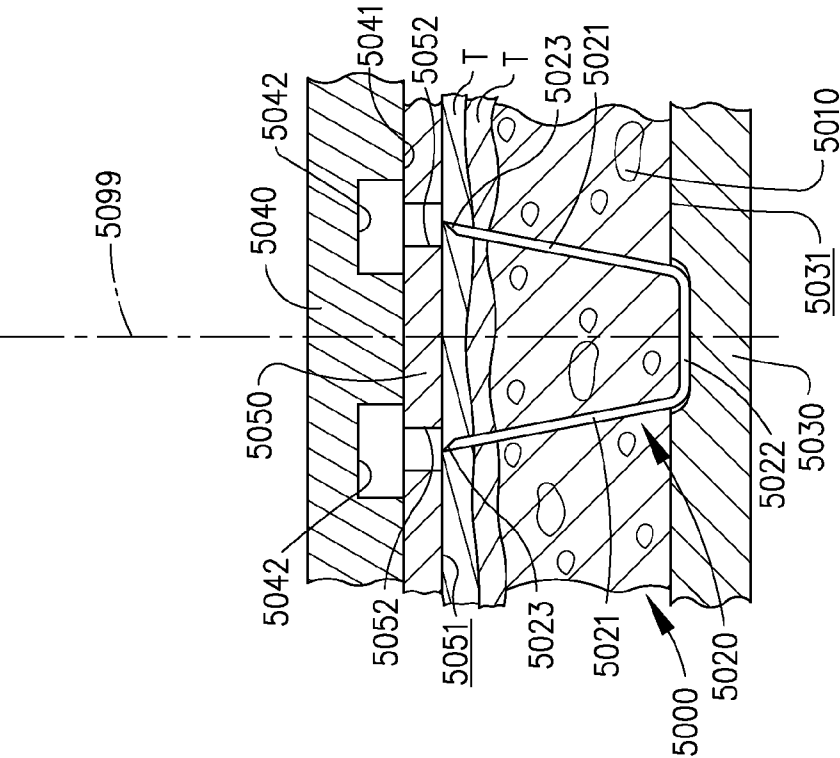


FIG. 161A

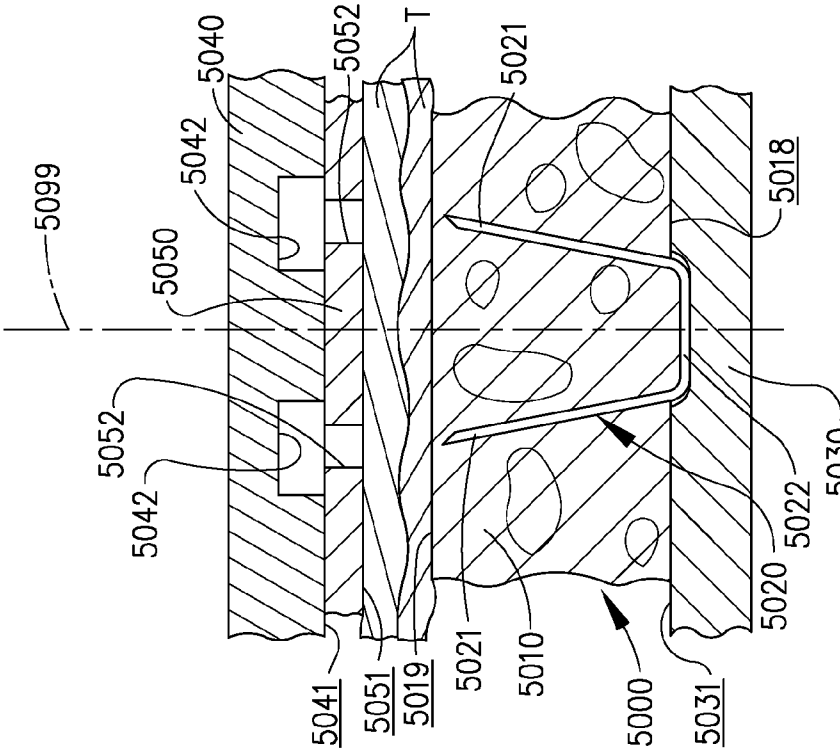


FIG. 161B

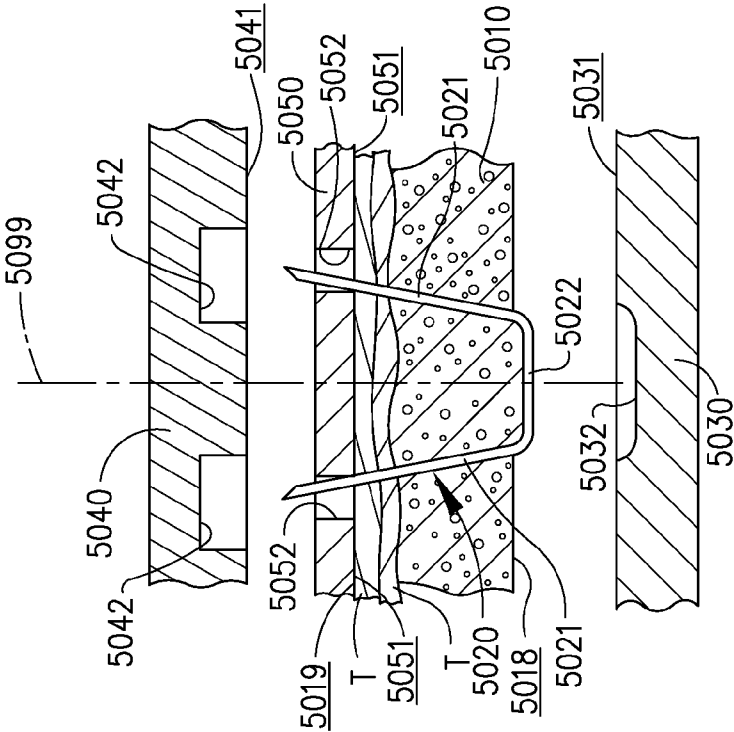


FIG. 161C

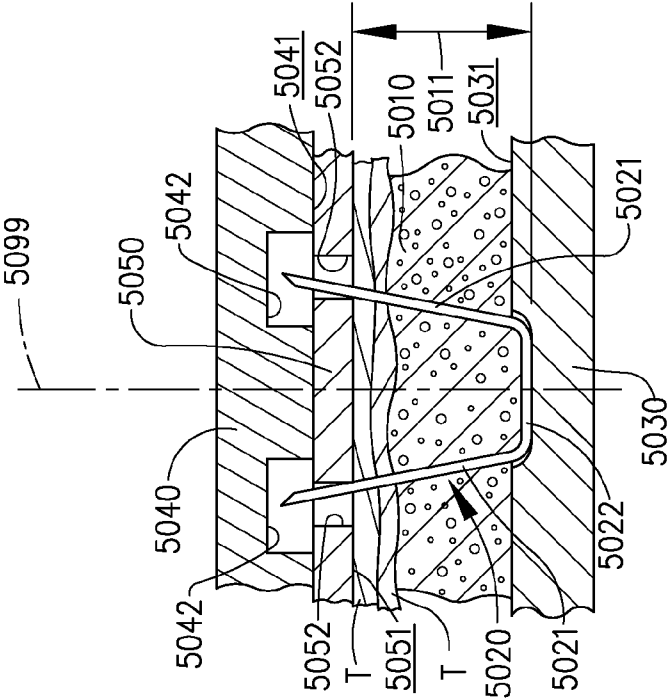


FIG. 161D

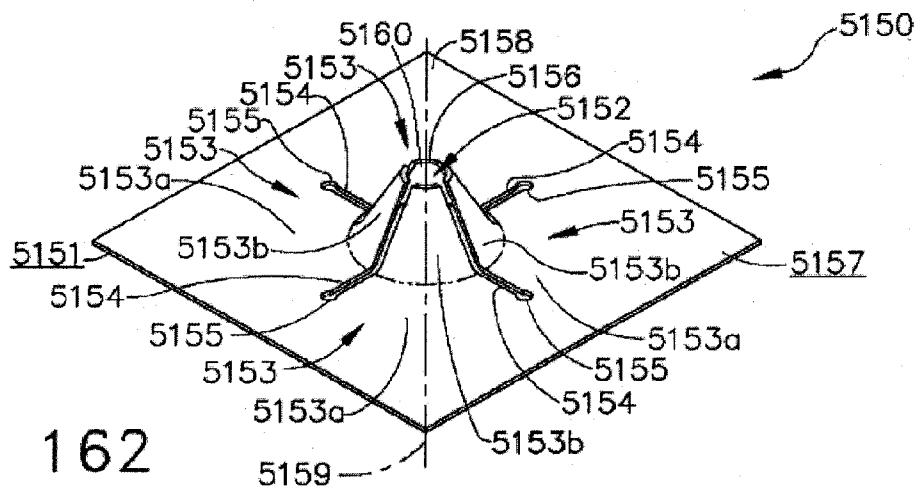


FIG. 162

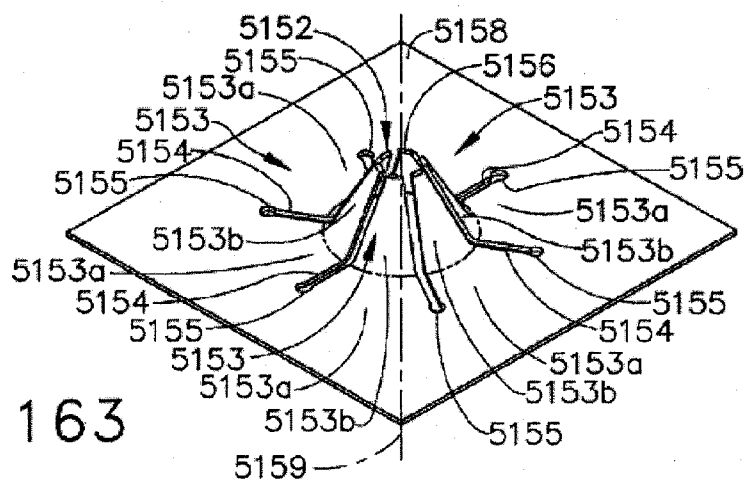


FIG. 163

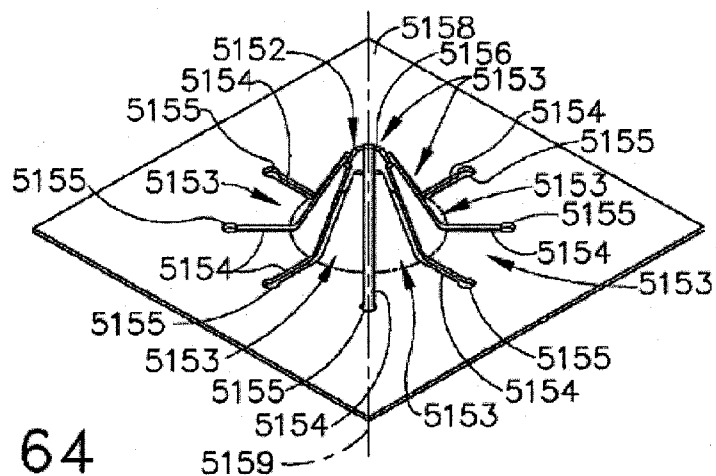
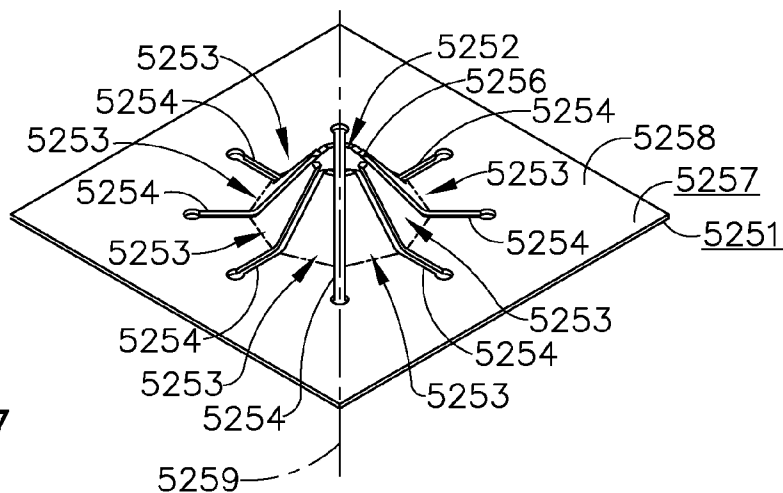
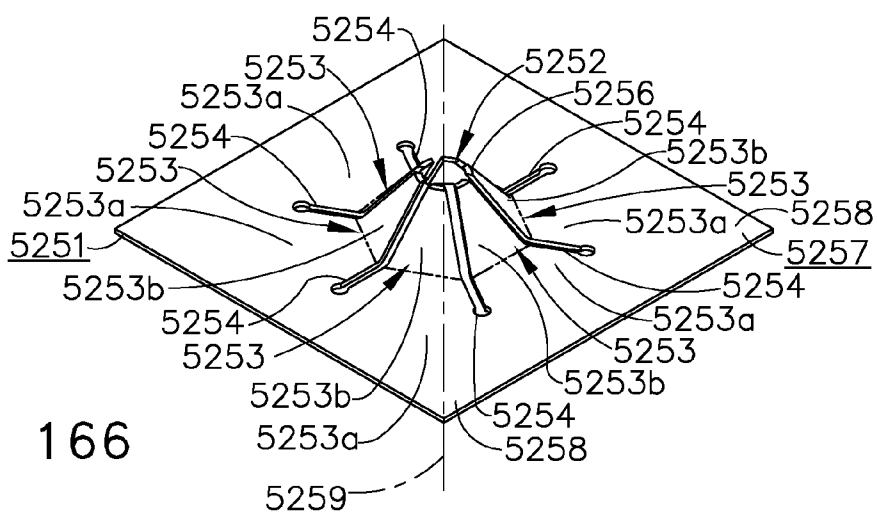
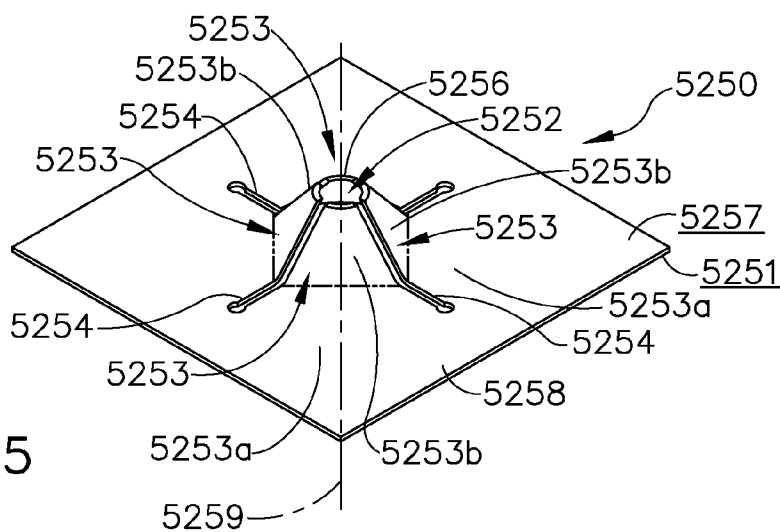


FIG. 164



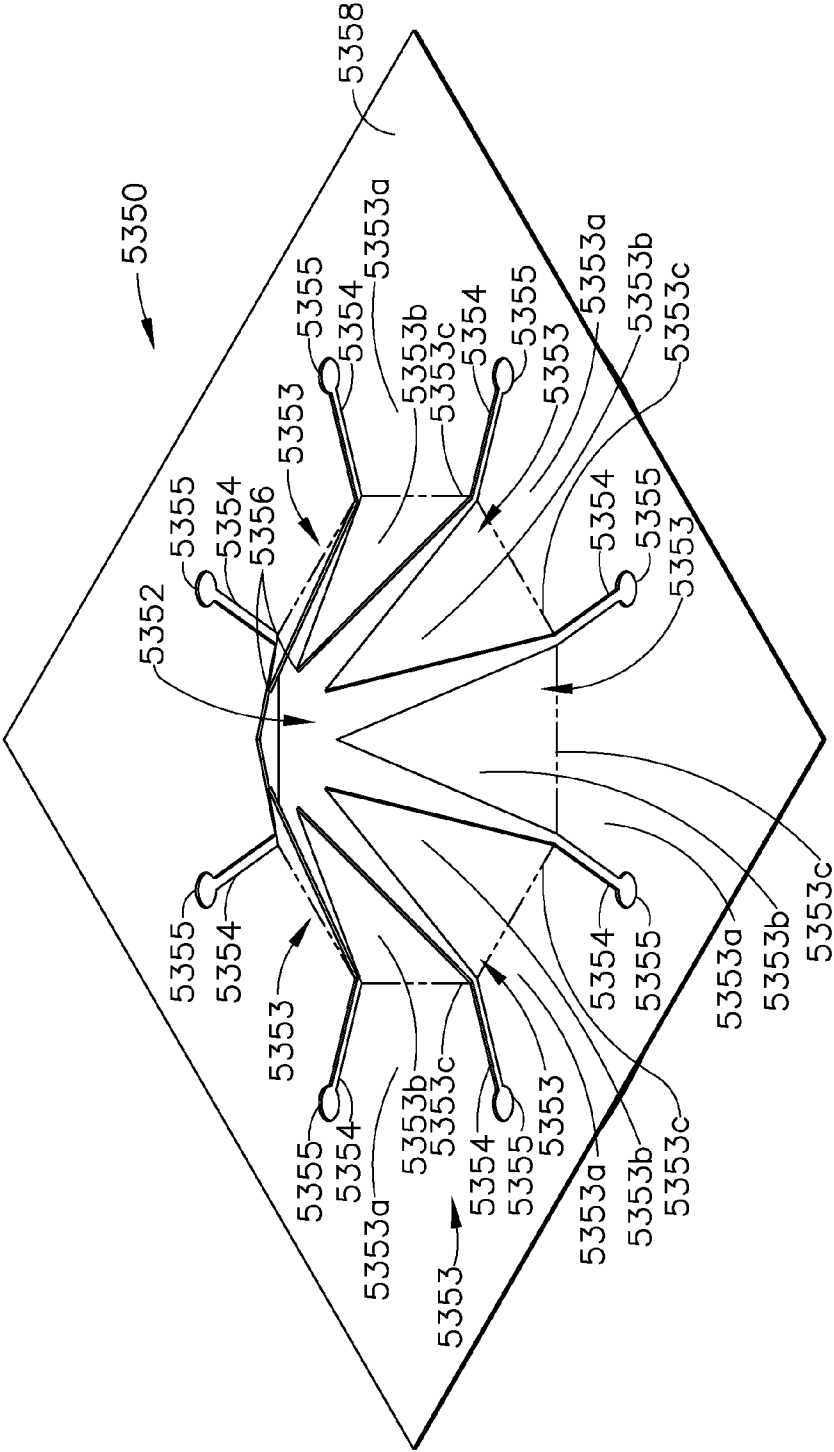


FIG. 168

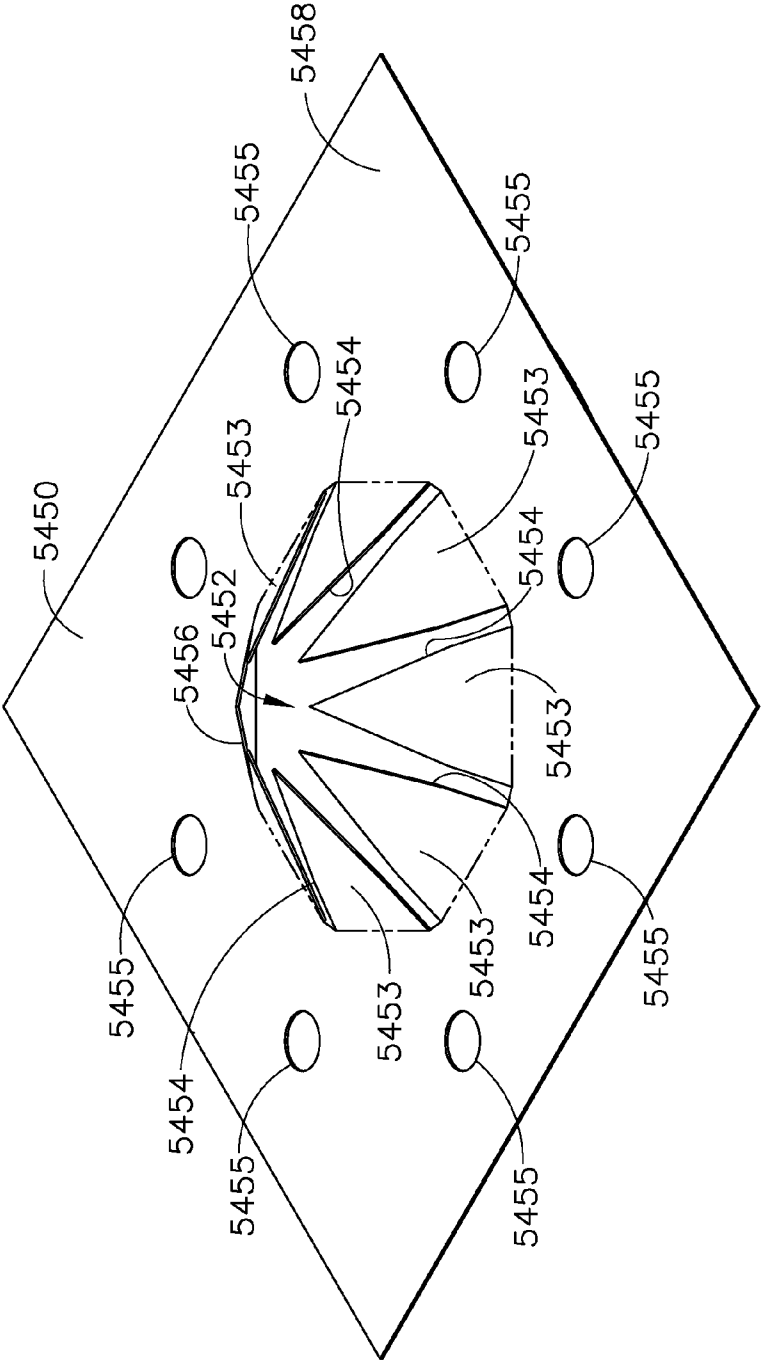


FIG. 169

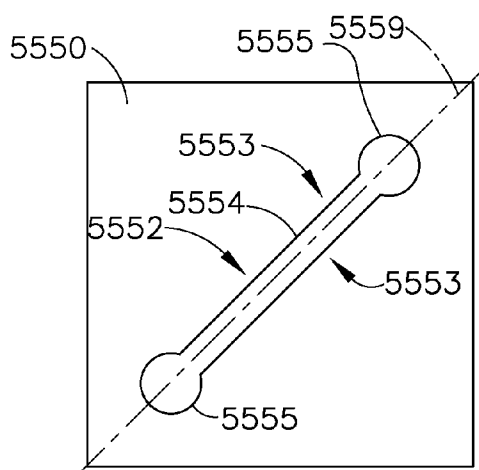


FIG. 170

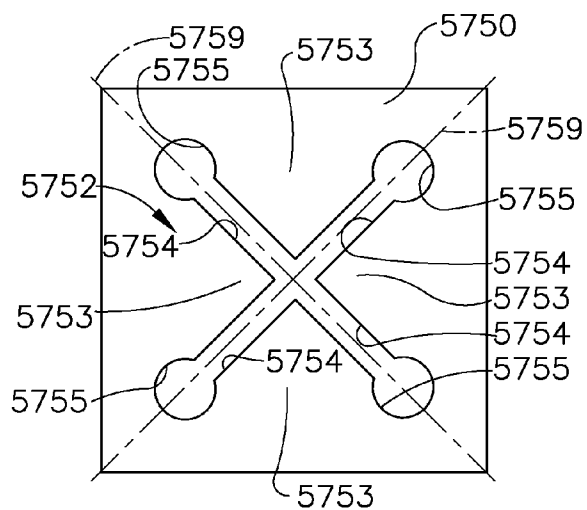


FIG. 172

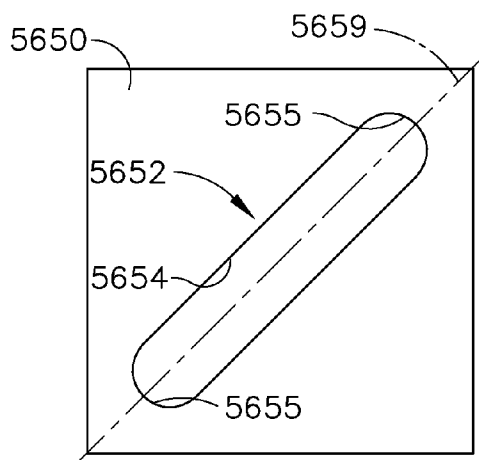


FIG. 171

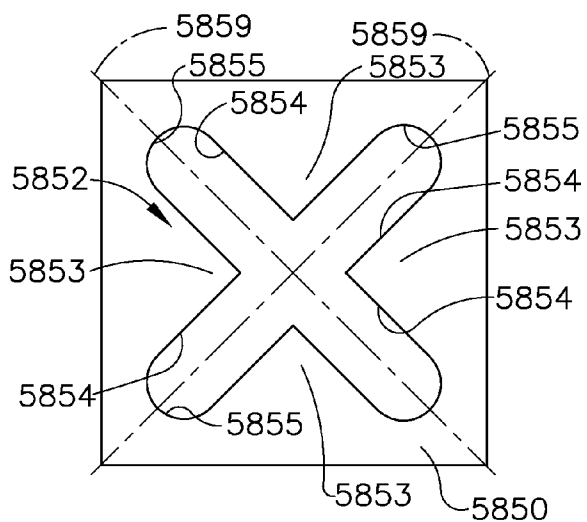


FIG. 173

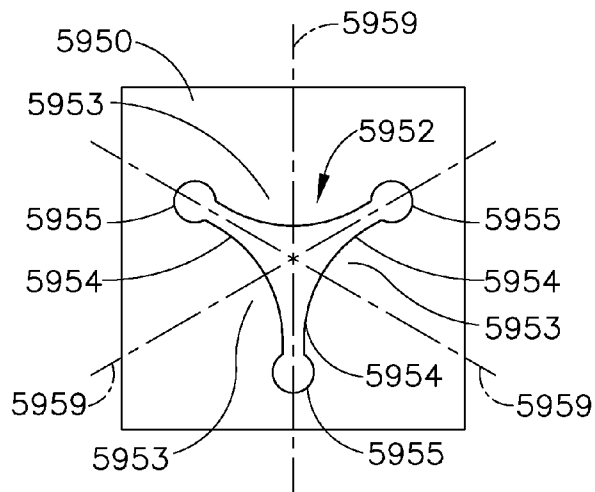


FIG. 174

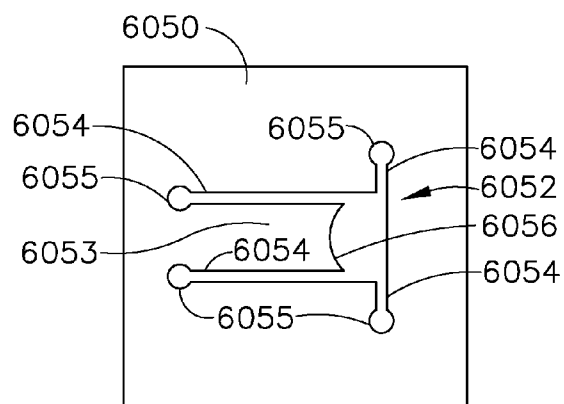


FIG. 175

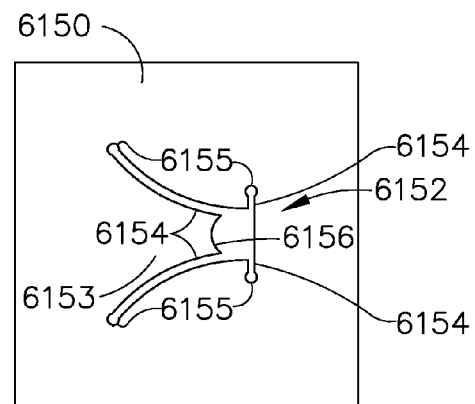
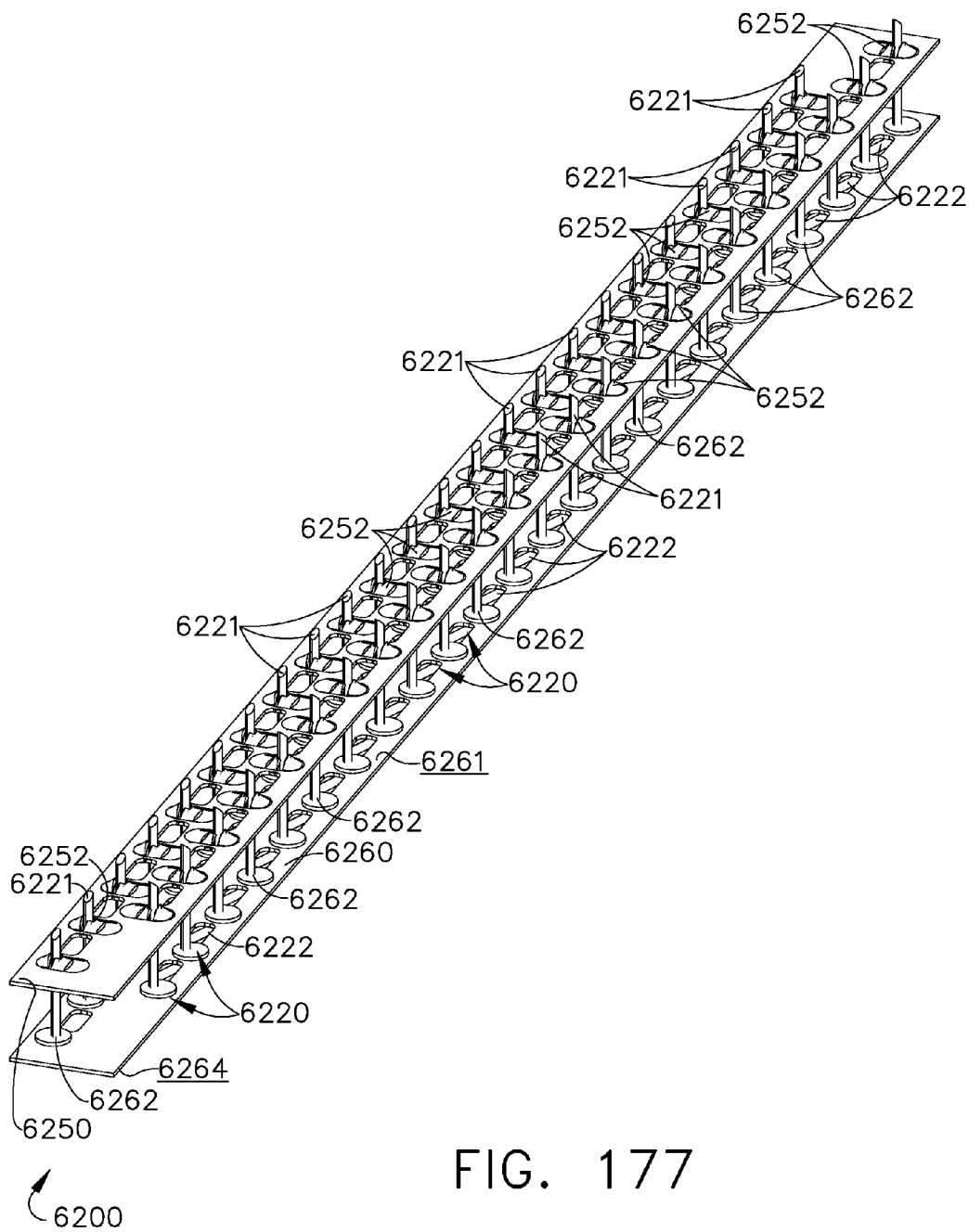


FIG. 176



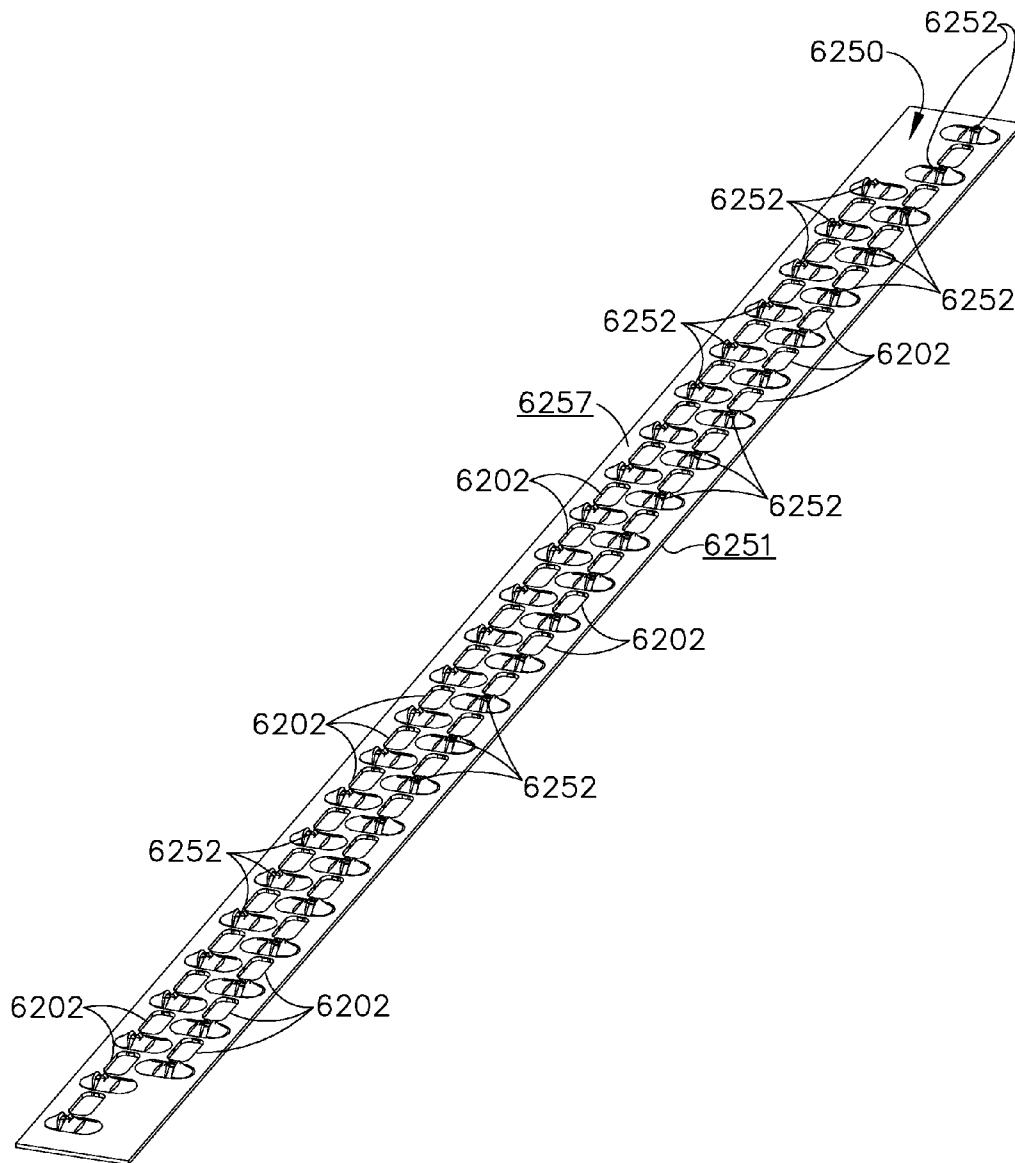


FIG. 178

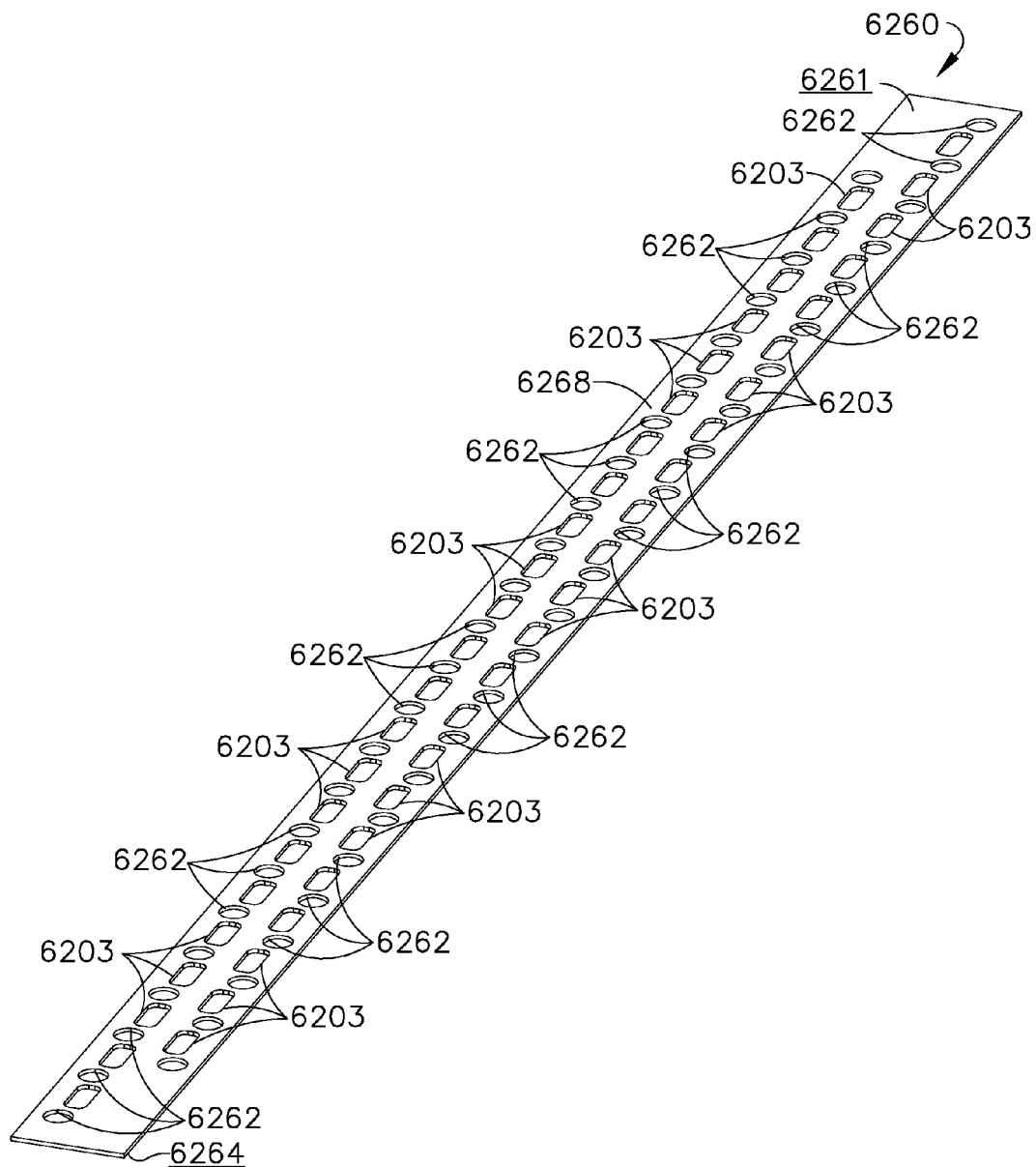


FIG. 179

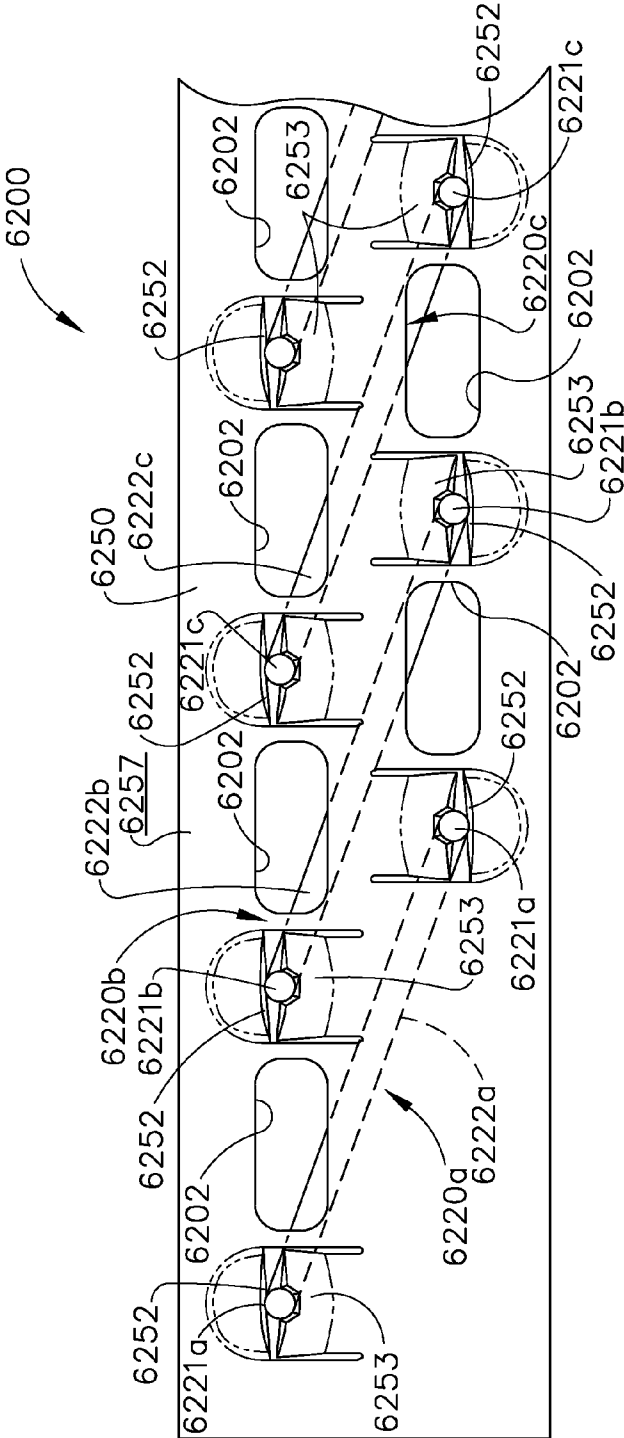


FIG. 180

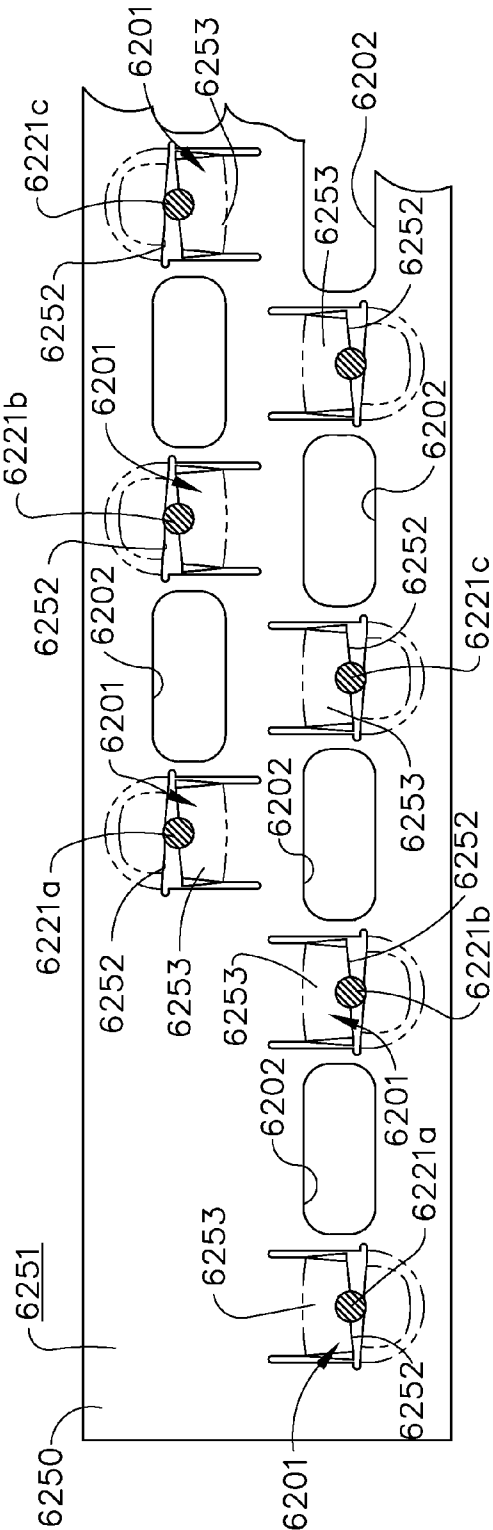


FIG. 181

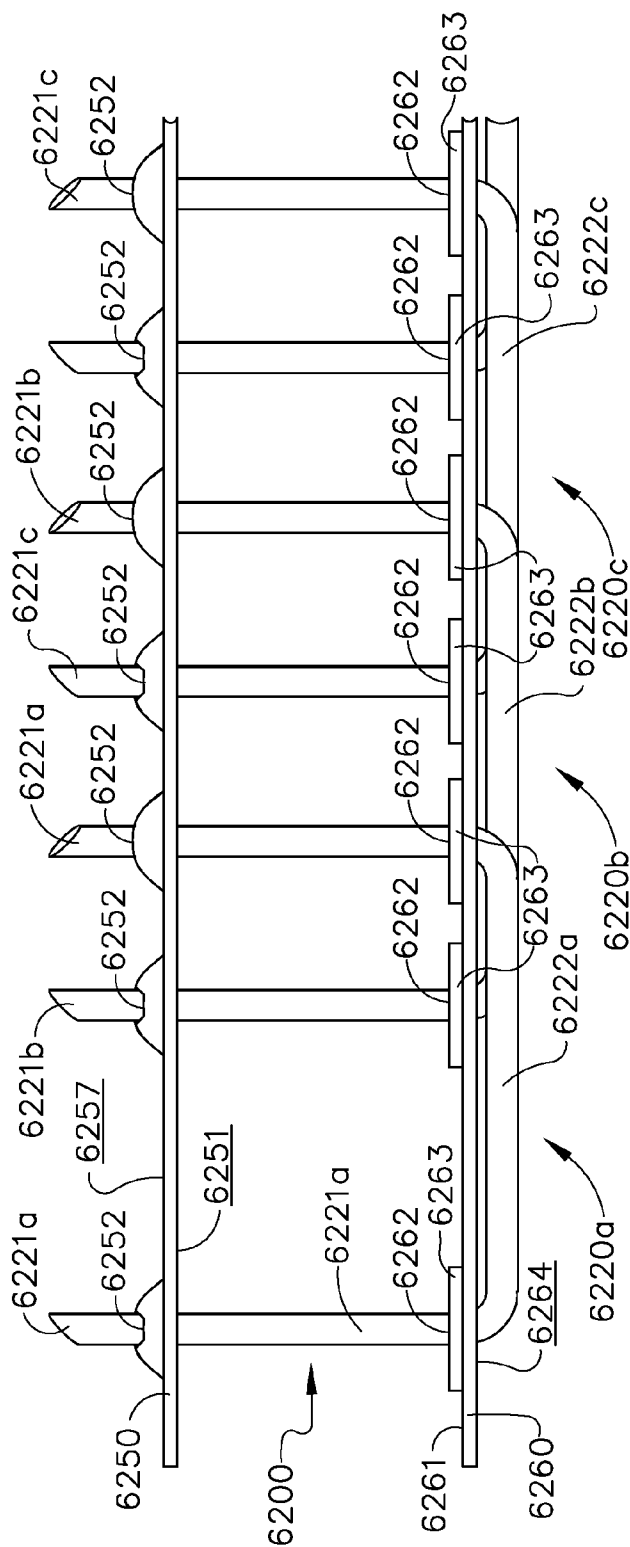


FIG. 182

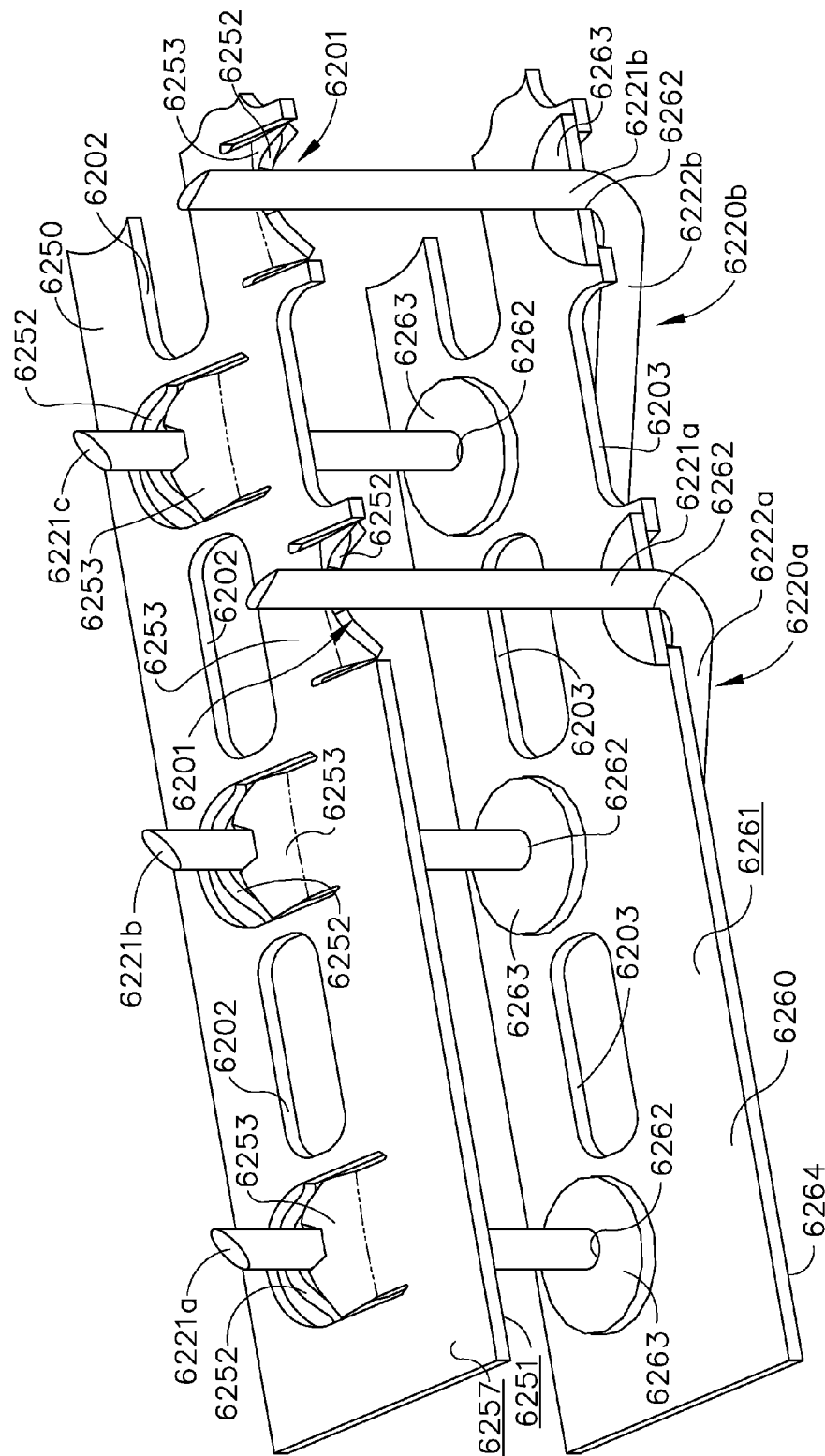


FIG. 183

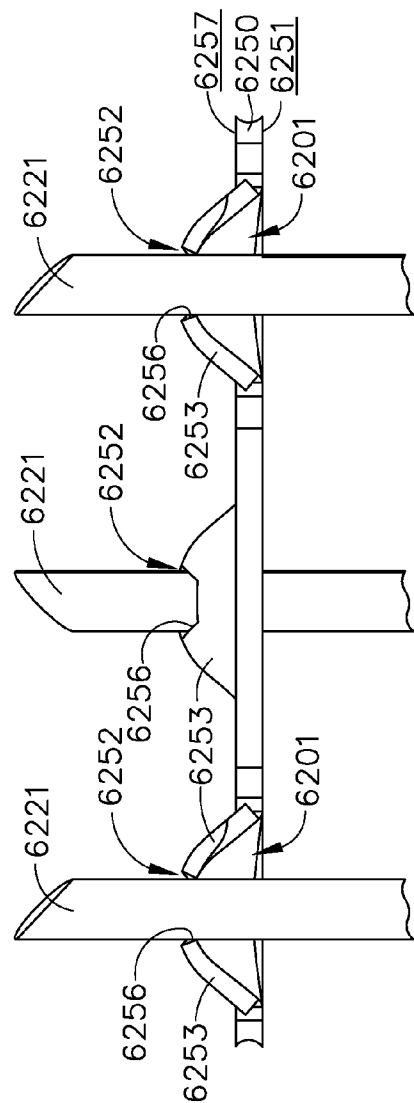


FIG. 184

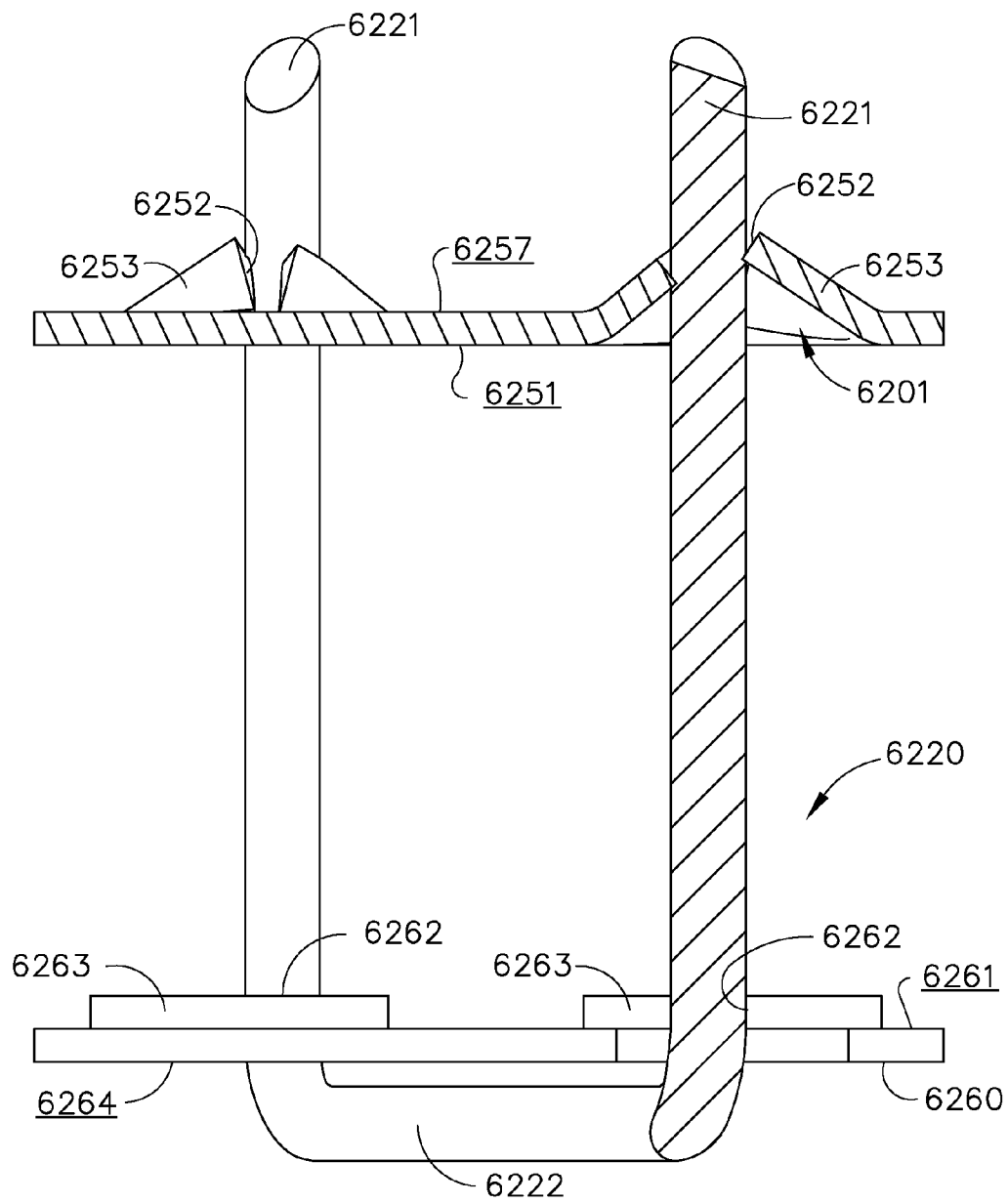


FIG. 185

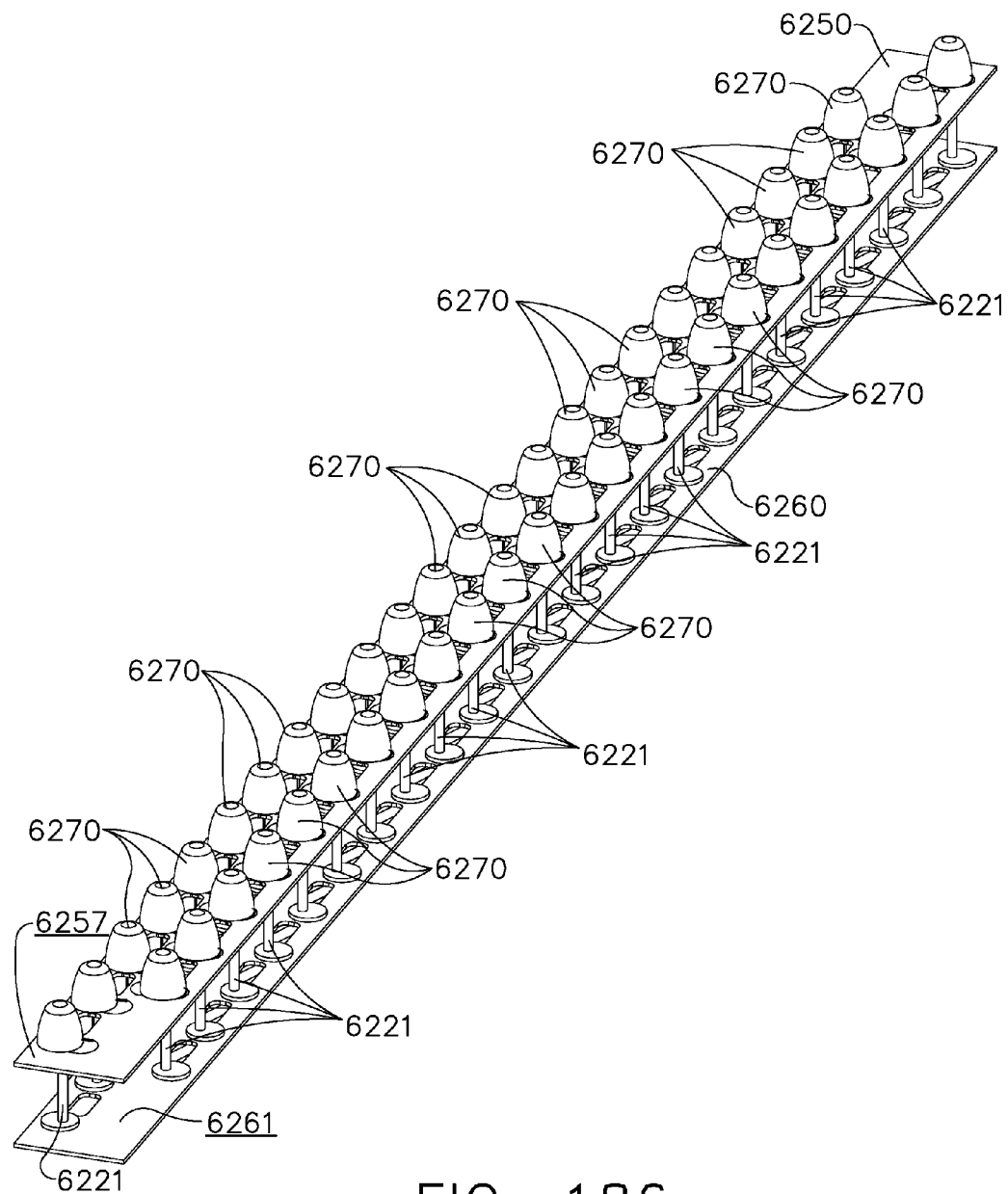


FIG. 186

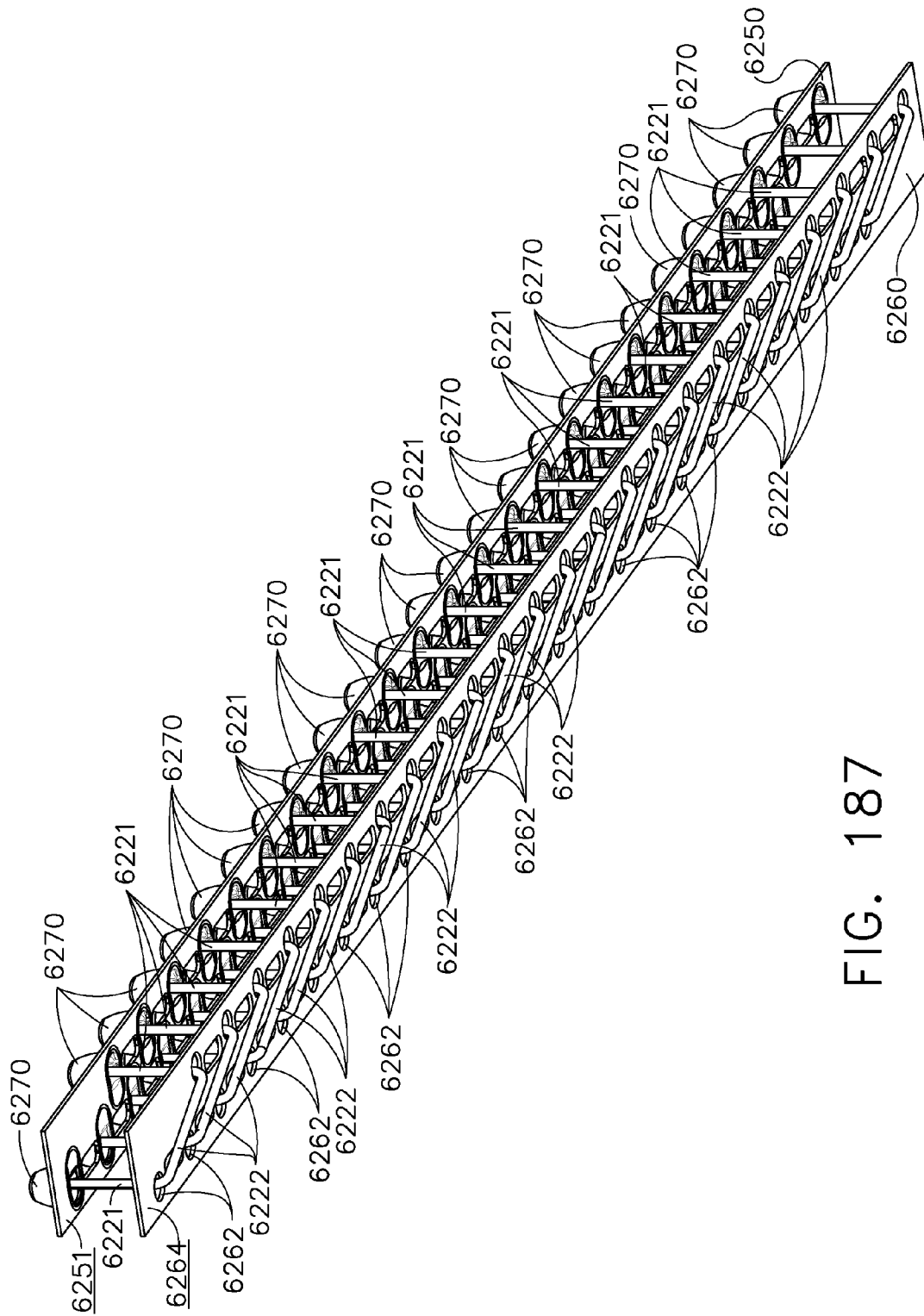


FIG. 187

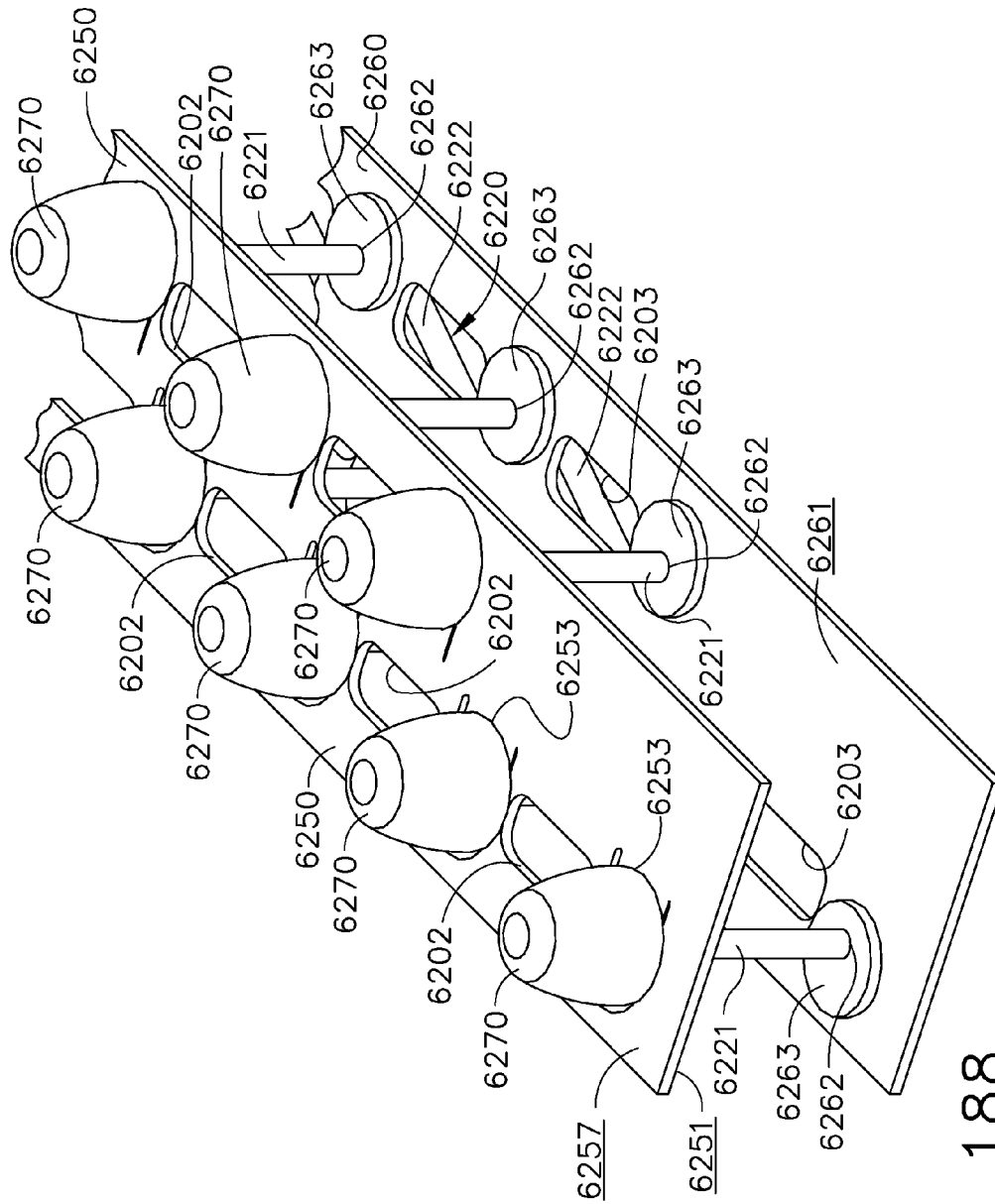


FIG. 188

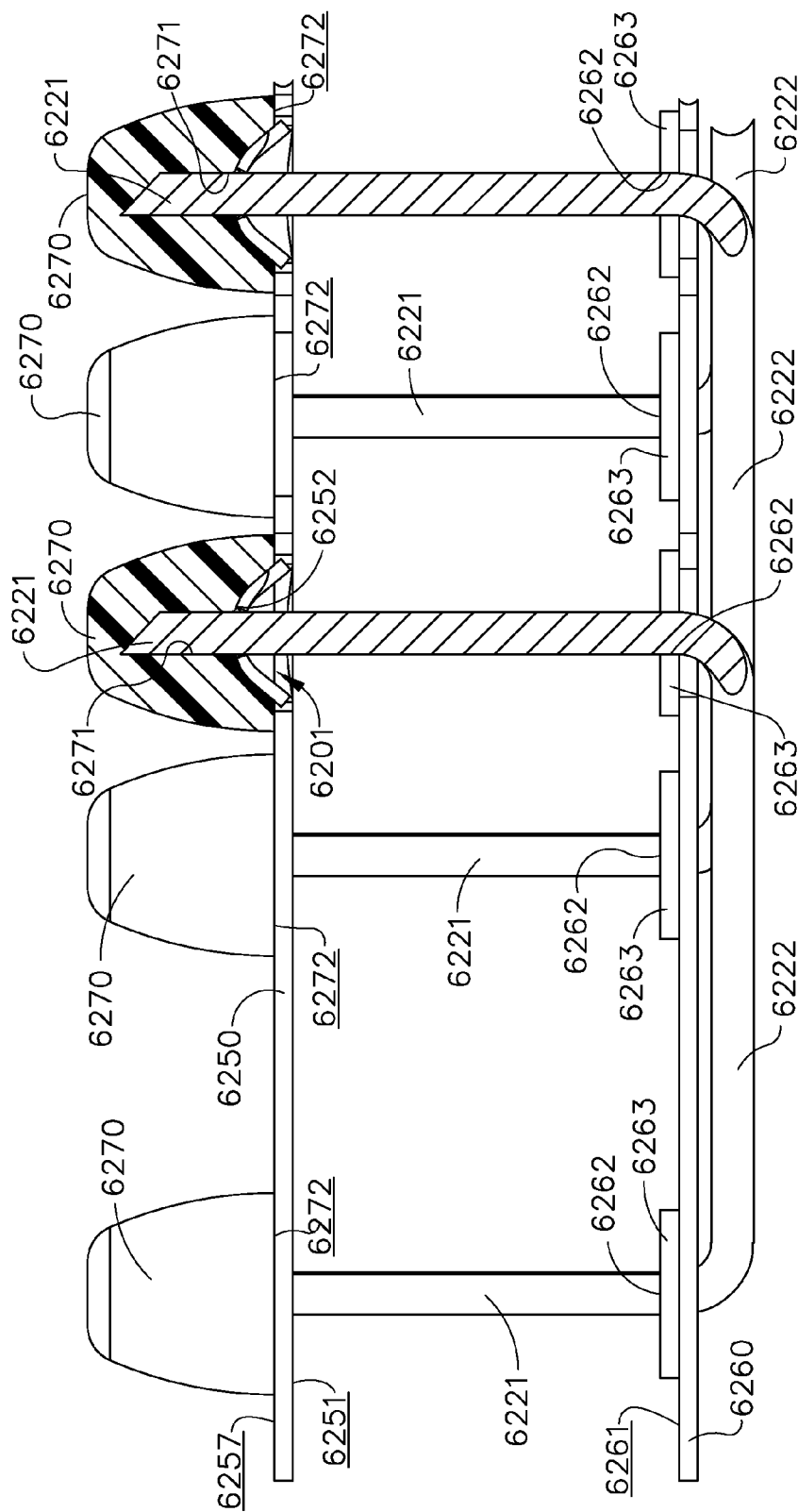


FIG. 189

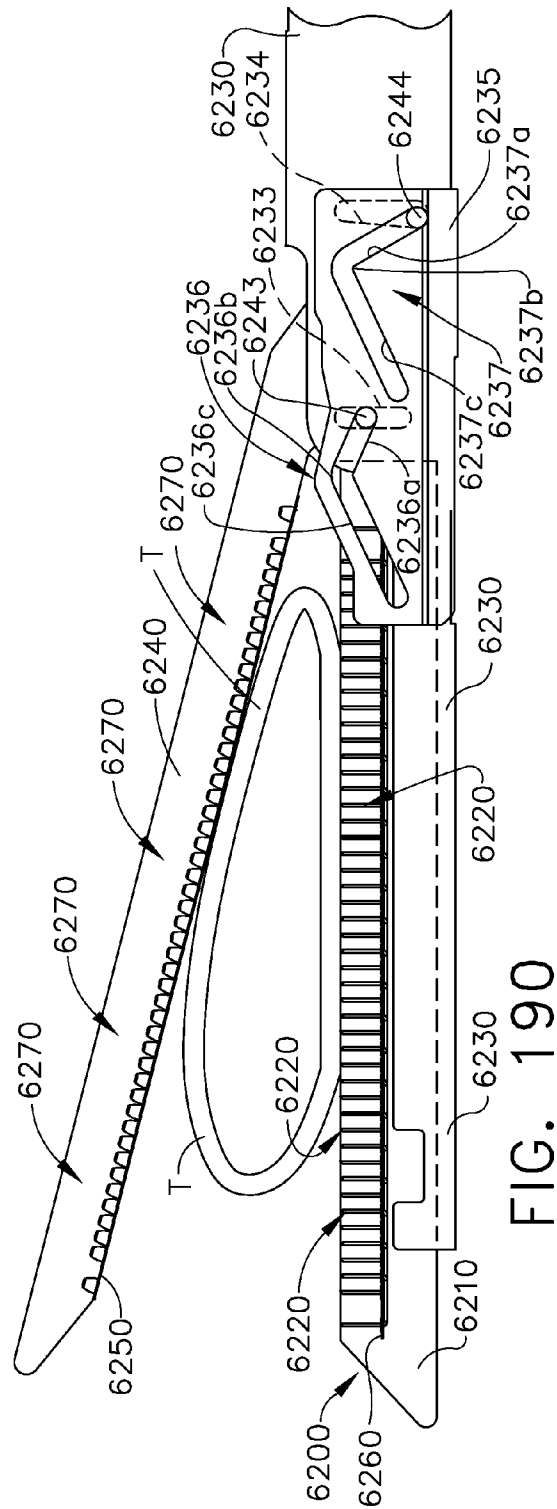


FIG. 190

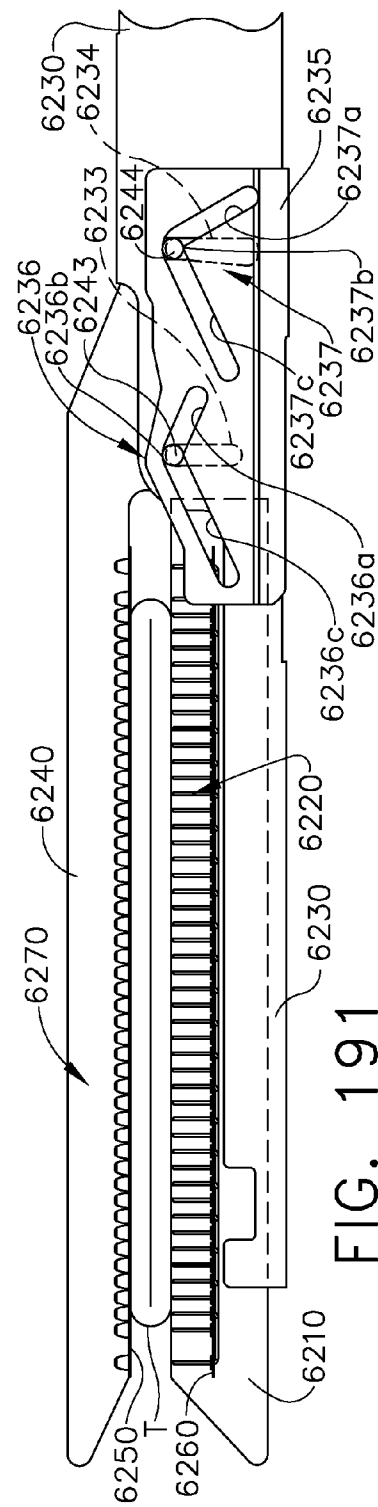


FIG. 191

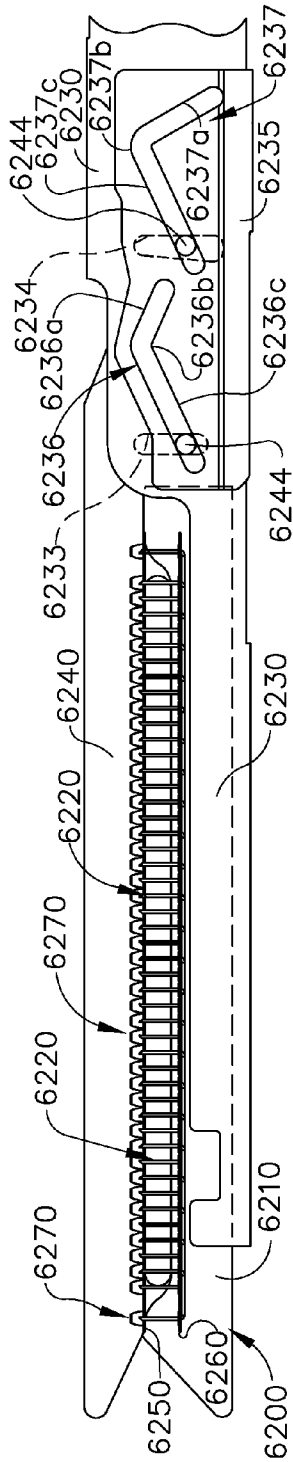


FIG. 192

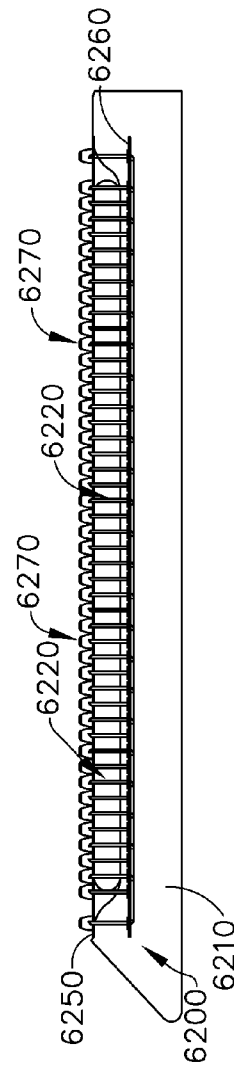


FIG. 193

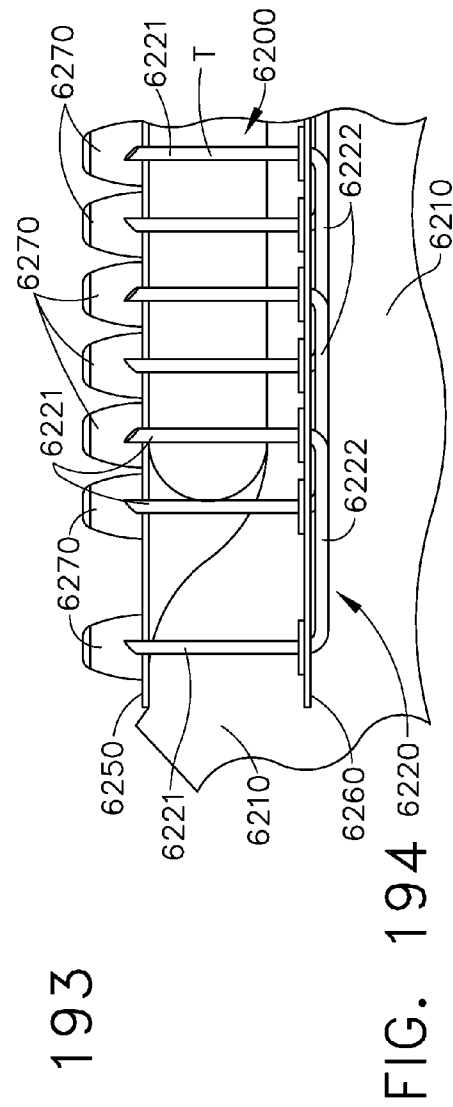


FIG. 194

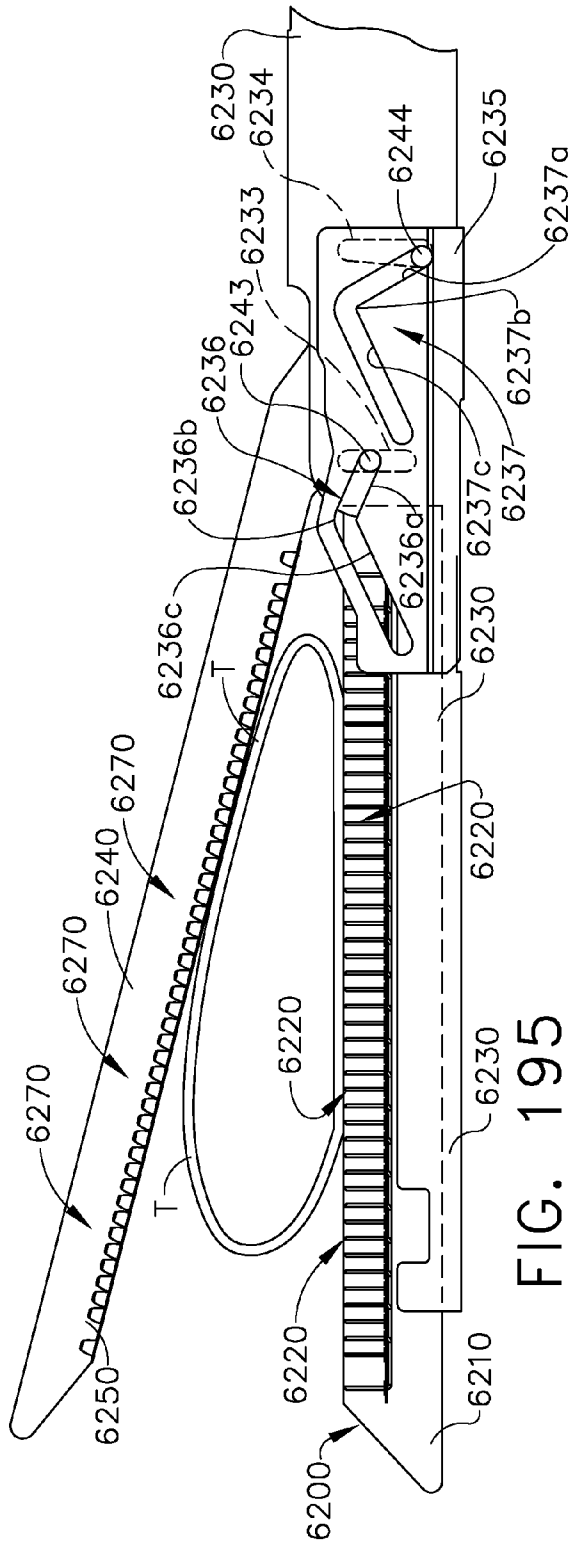


FIG. 195

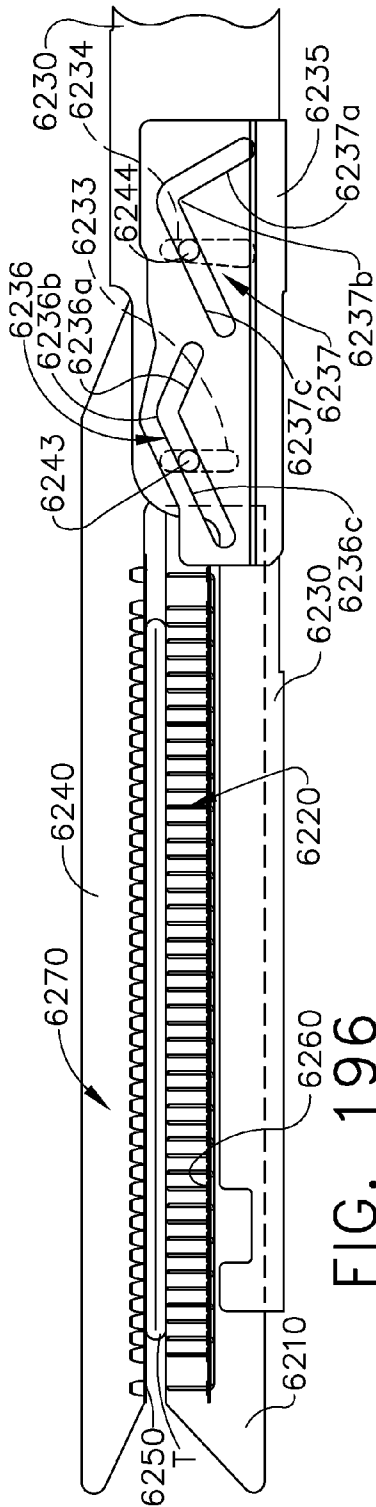


FIG. 196

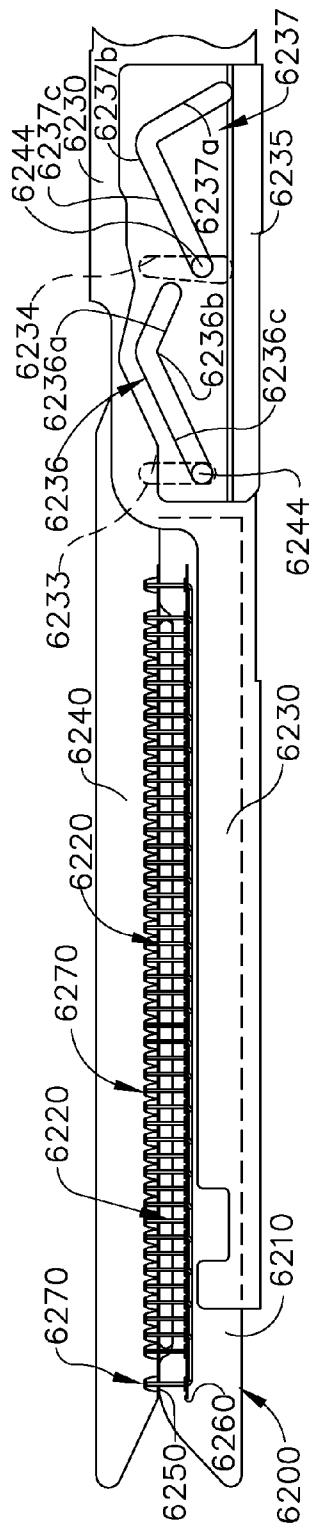


FIG. 197

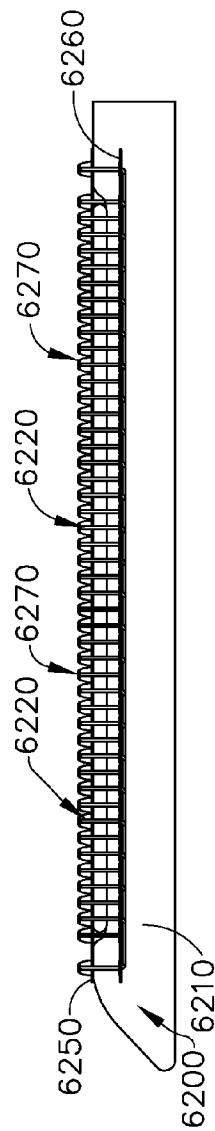


FIG. 198

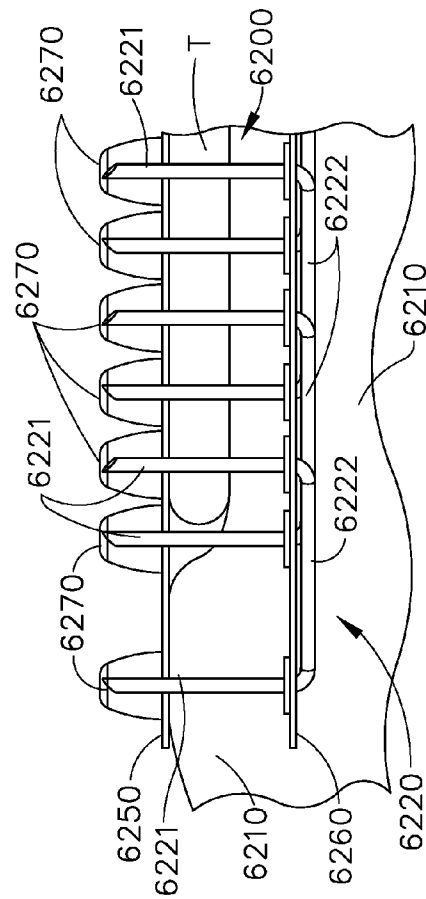


FIG. 199

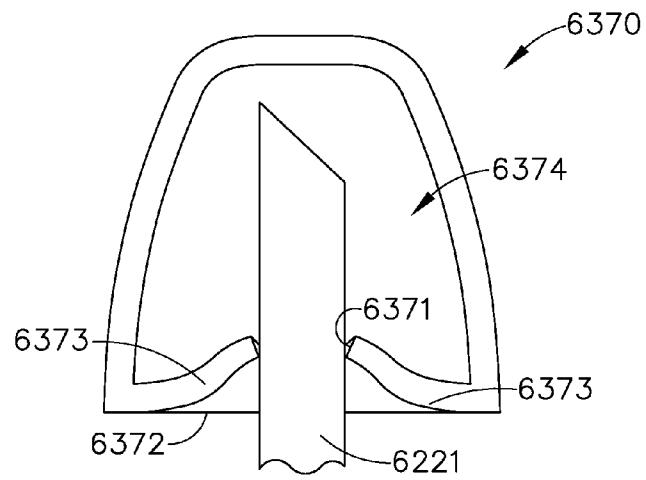


FIG. 200

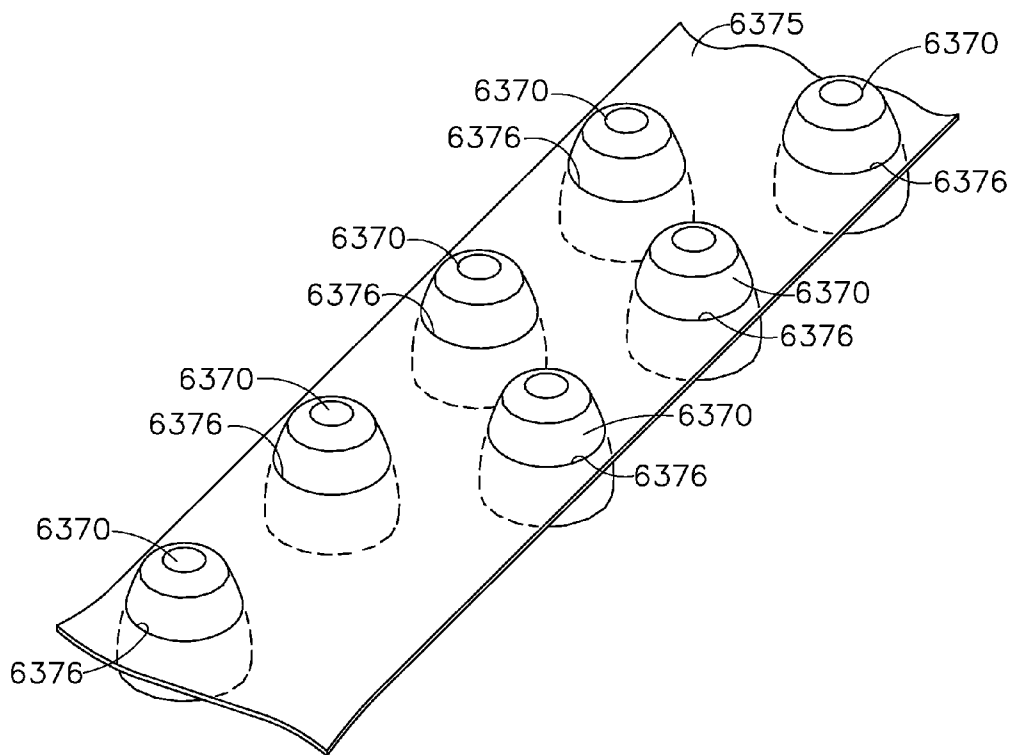


FIG. 201

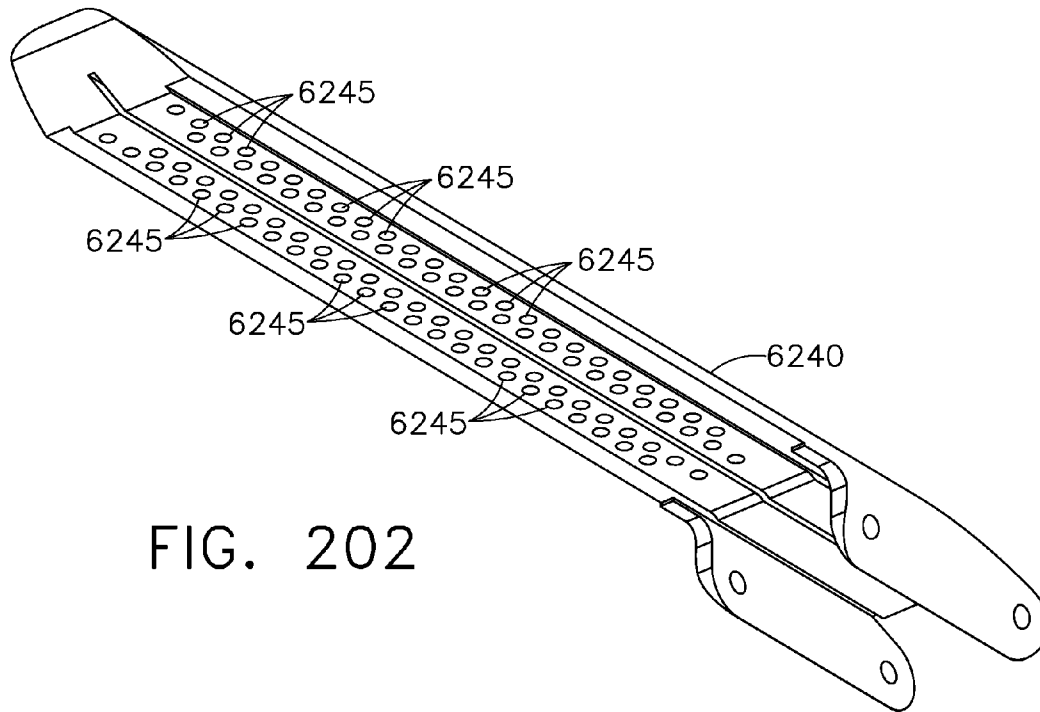


FIG. 202

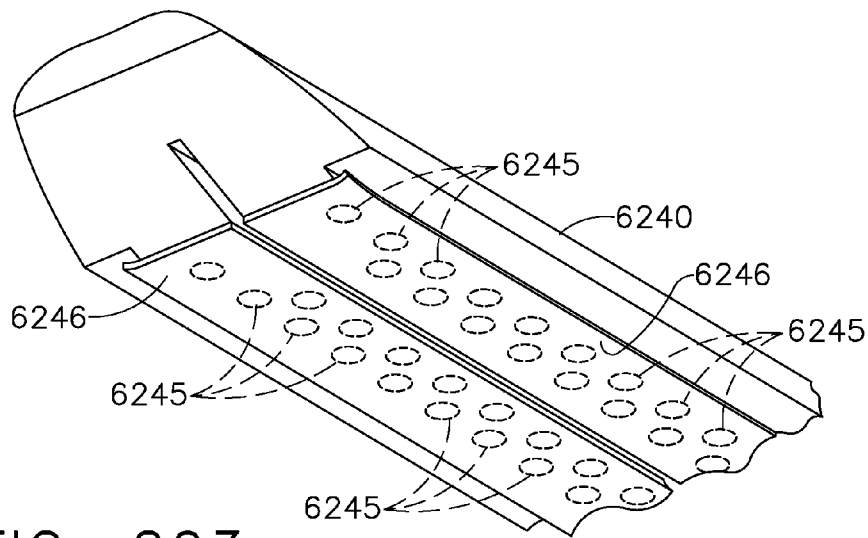


FIG. 203

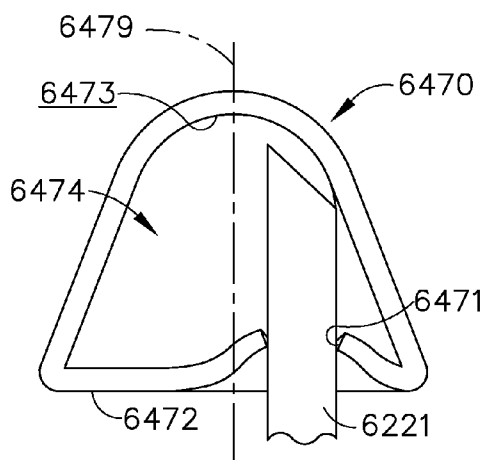


FIG. 204

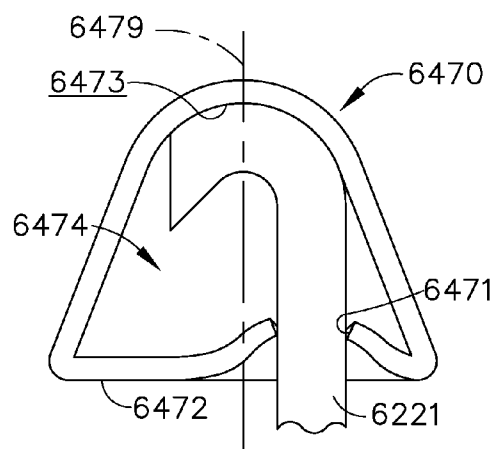


FIG. 205

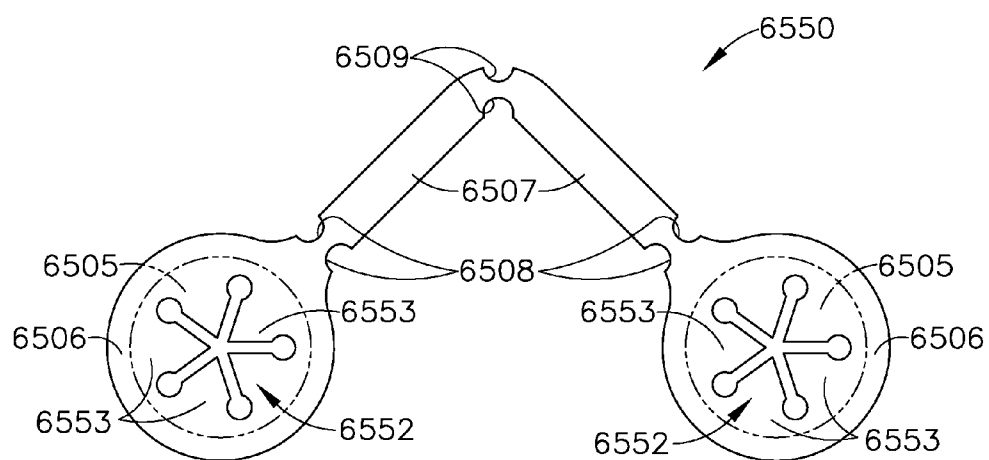


FIG. 206

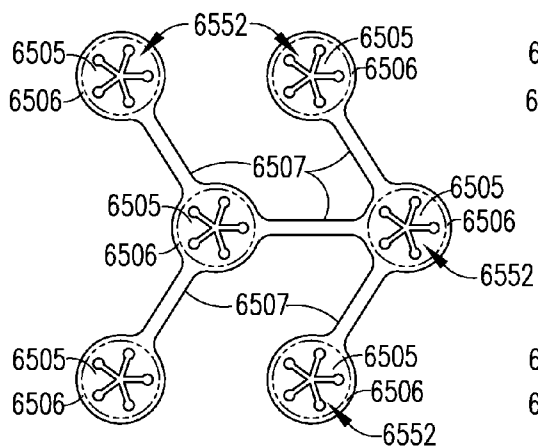


FIG. 207

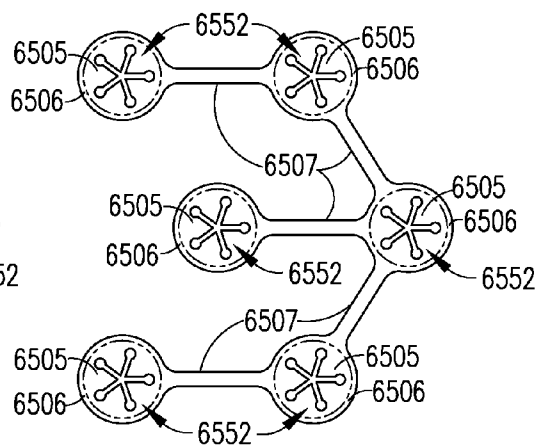


FIG. 208

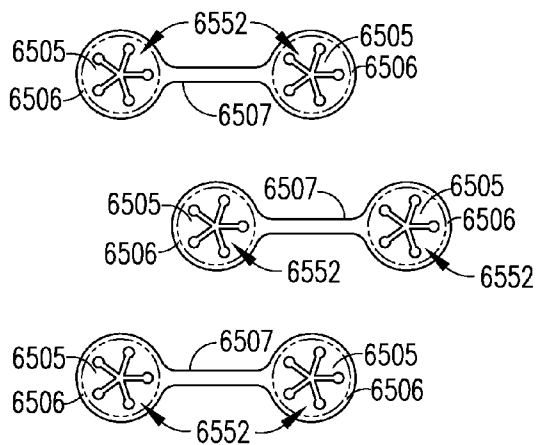


FIG. 209

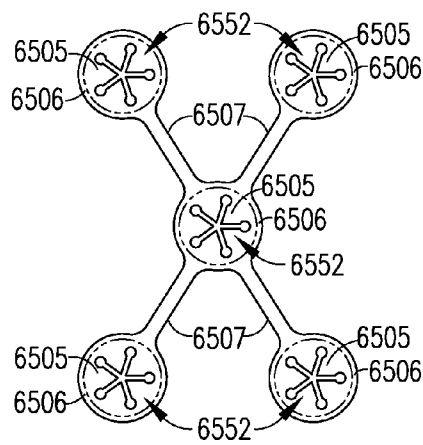


FIG. 210

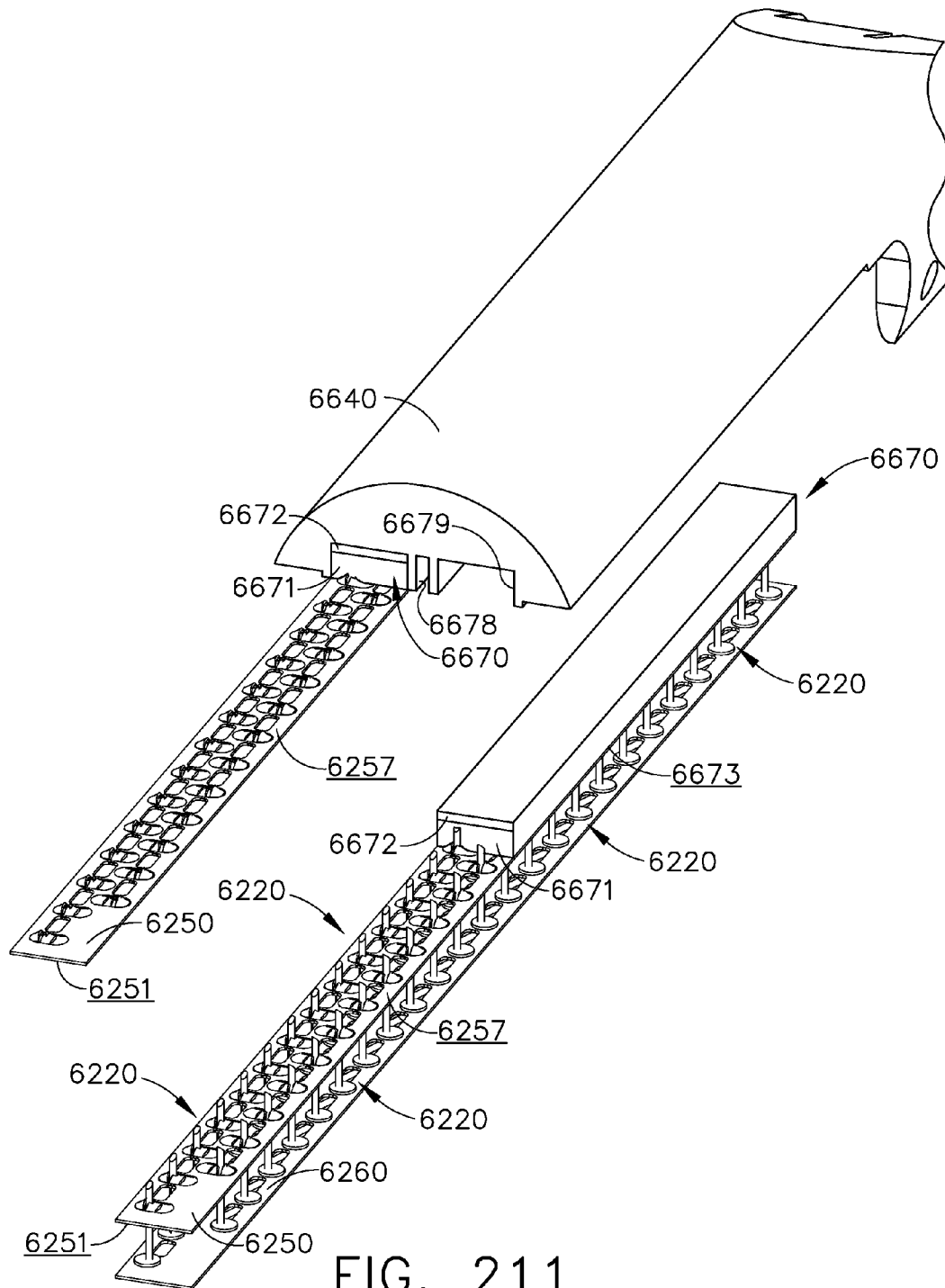


FIG. 211

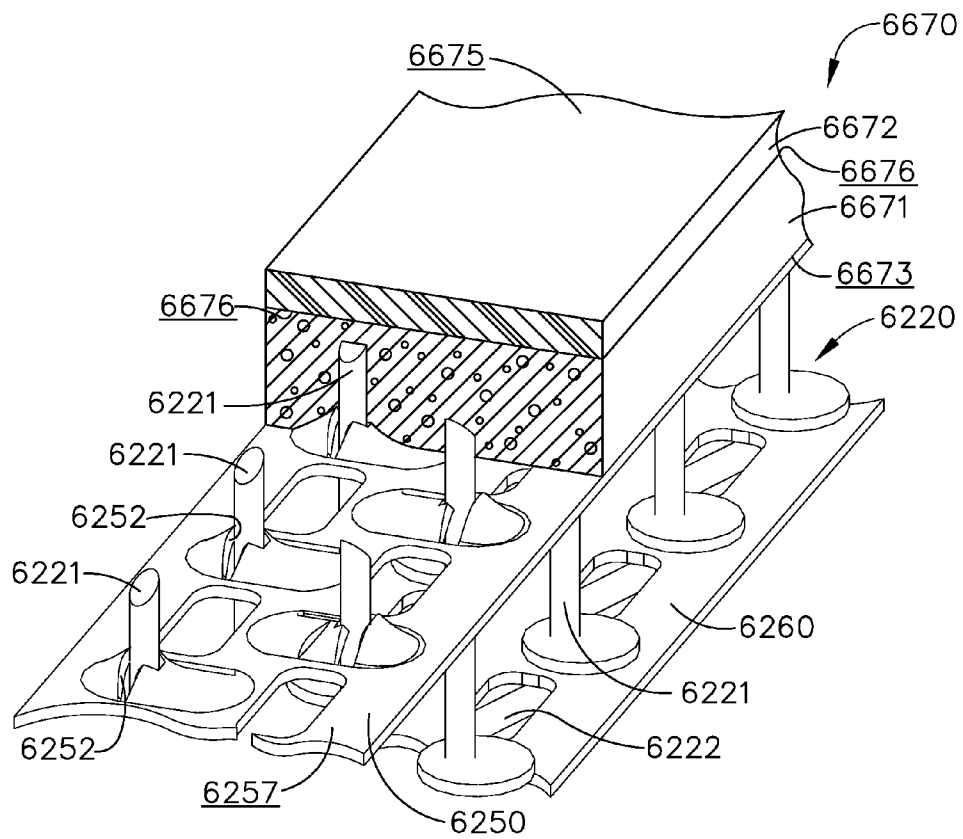


FIG. 212

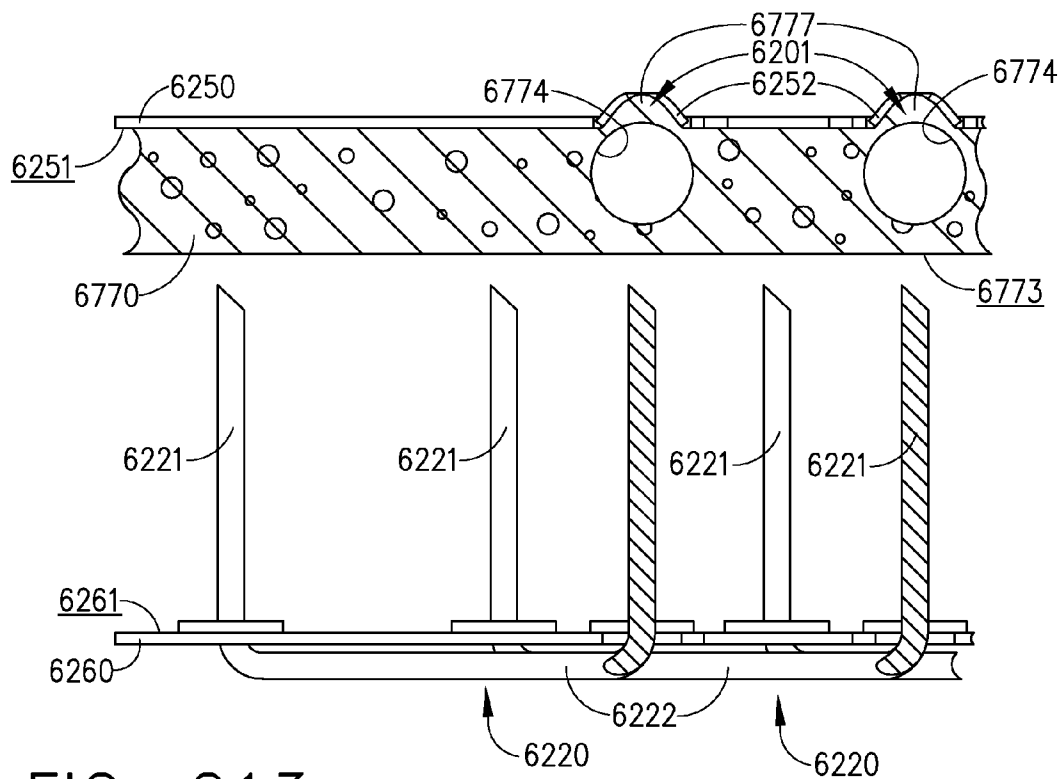


FIG. 213

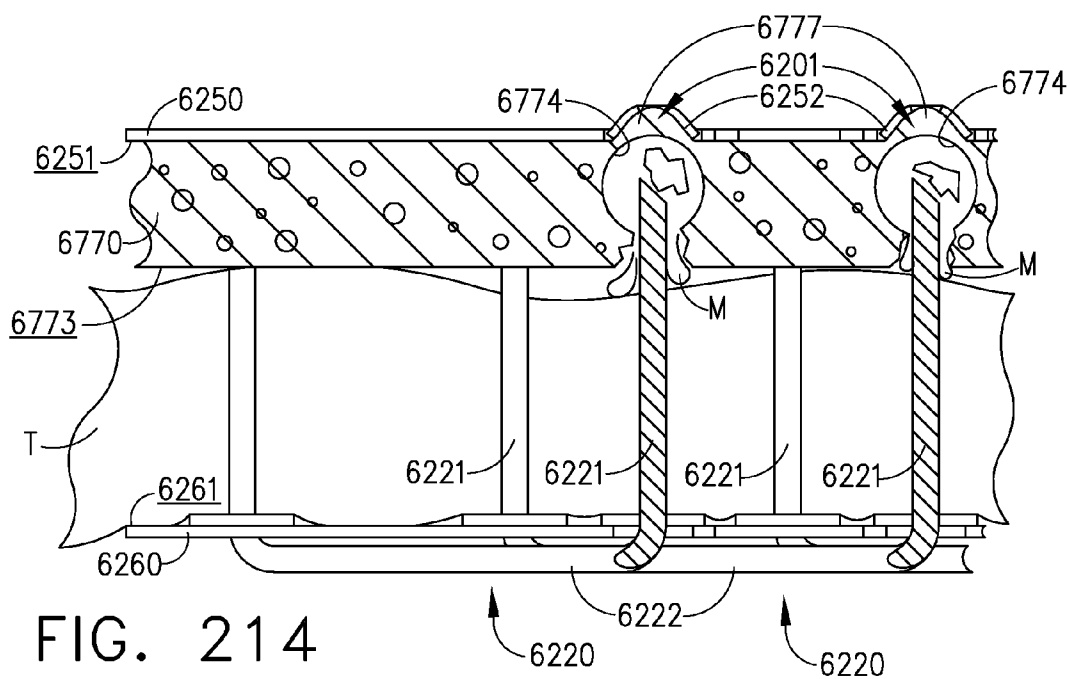


FIG. 214

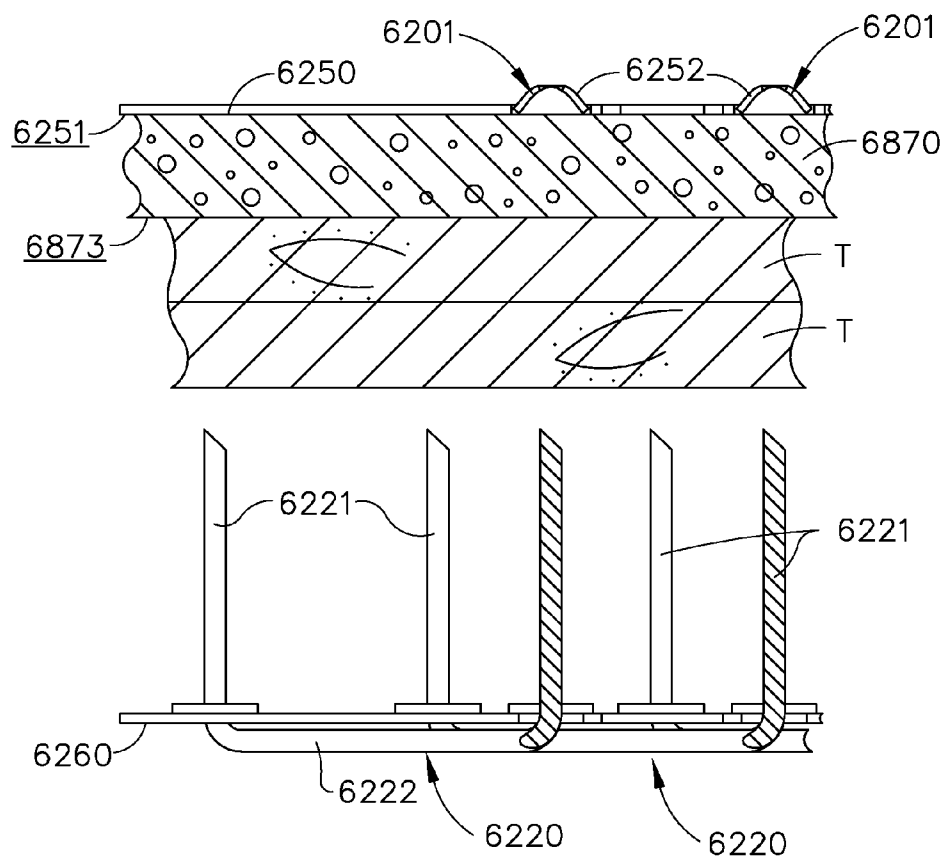


FIG. 215

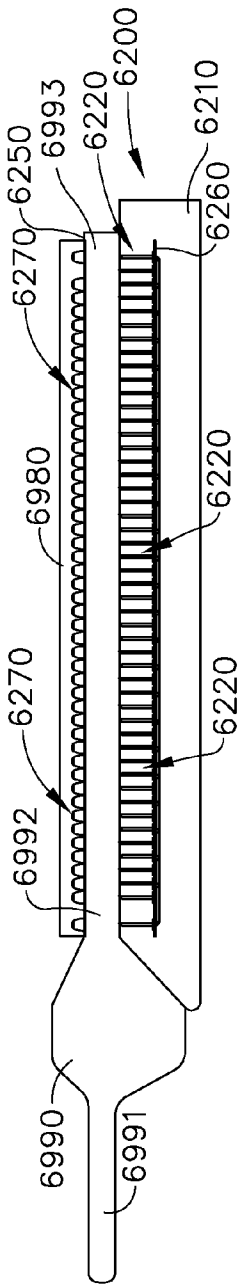


FIG. 216

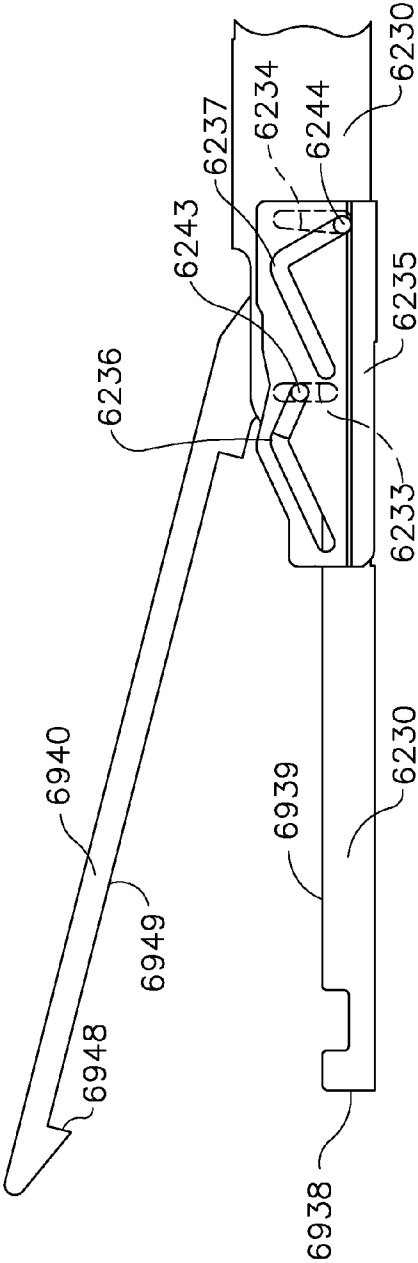
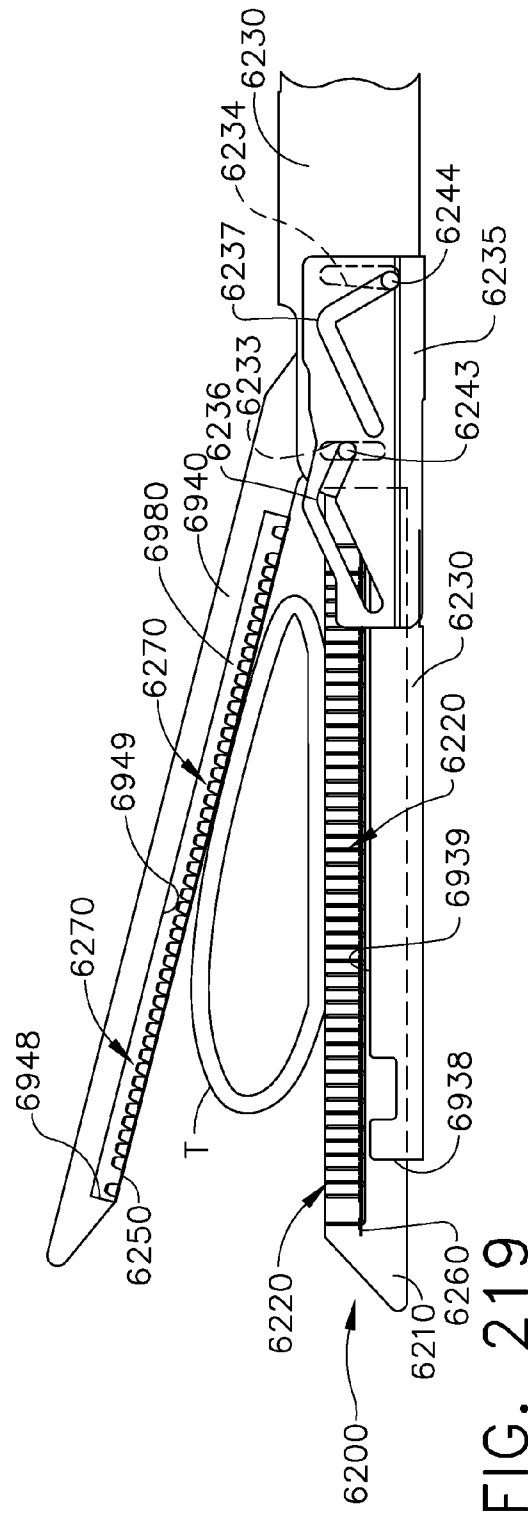
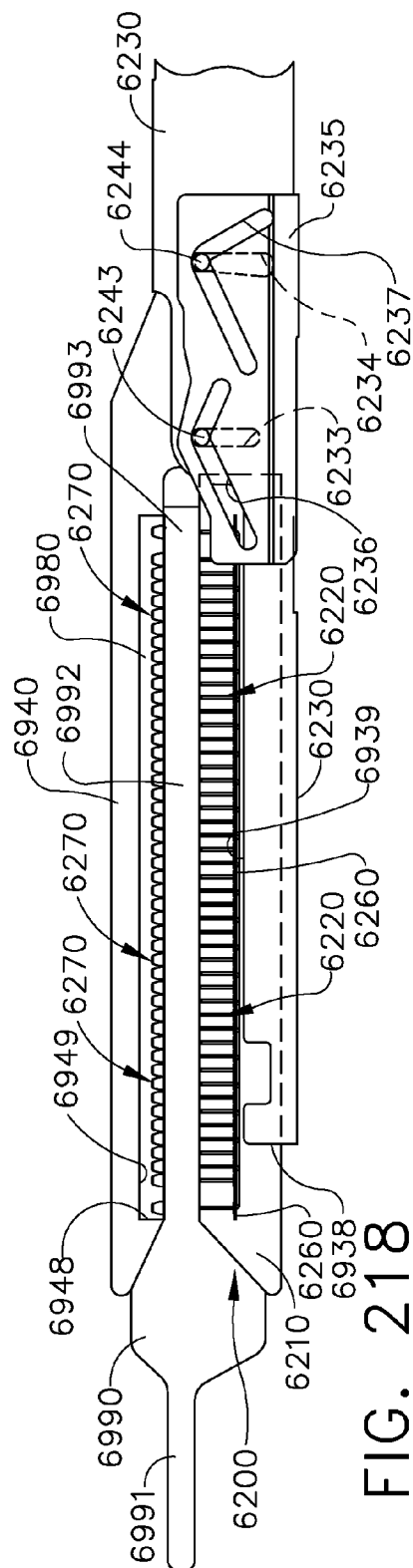
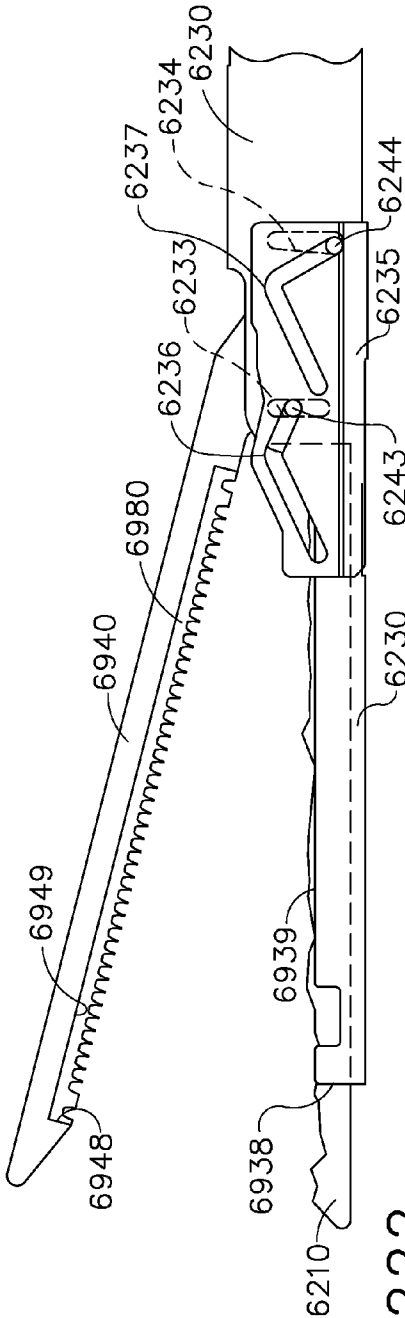
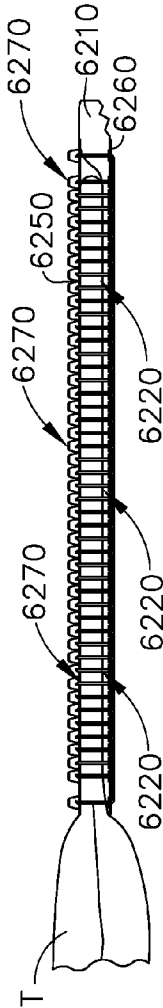
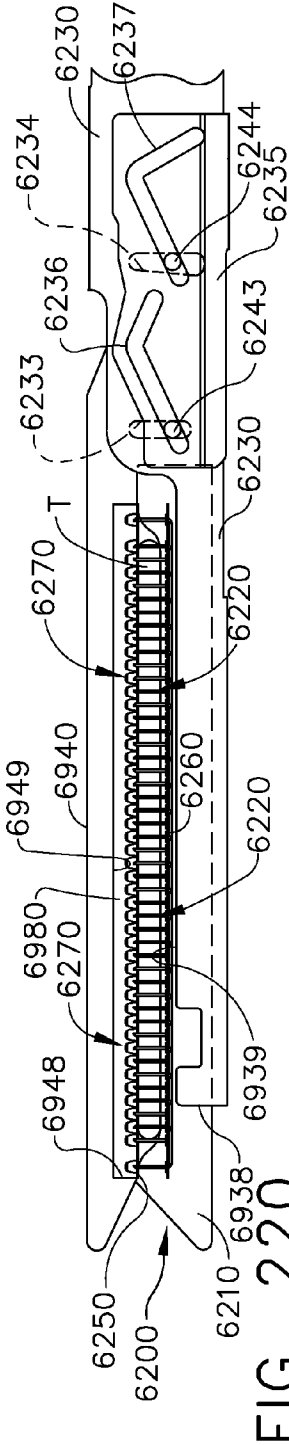
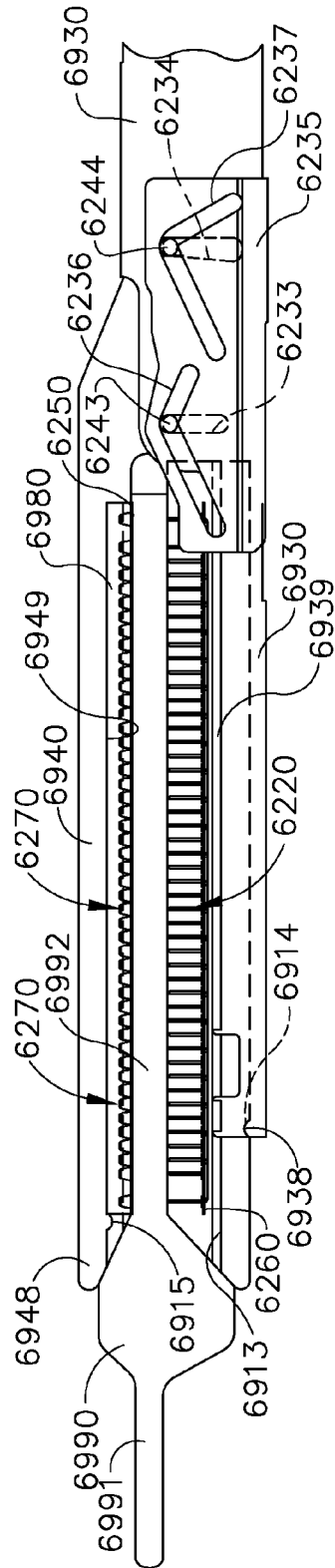
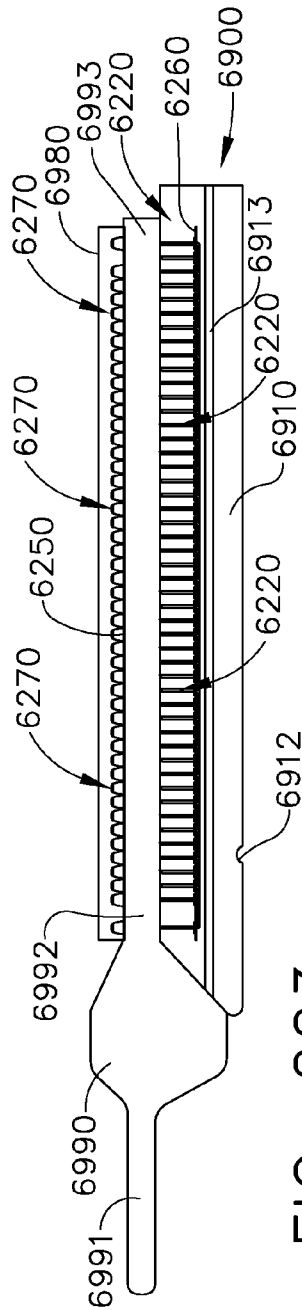


FIG. 217







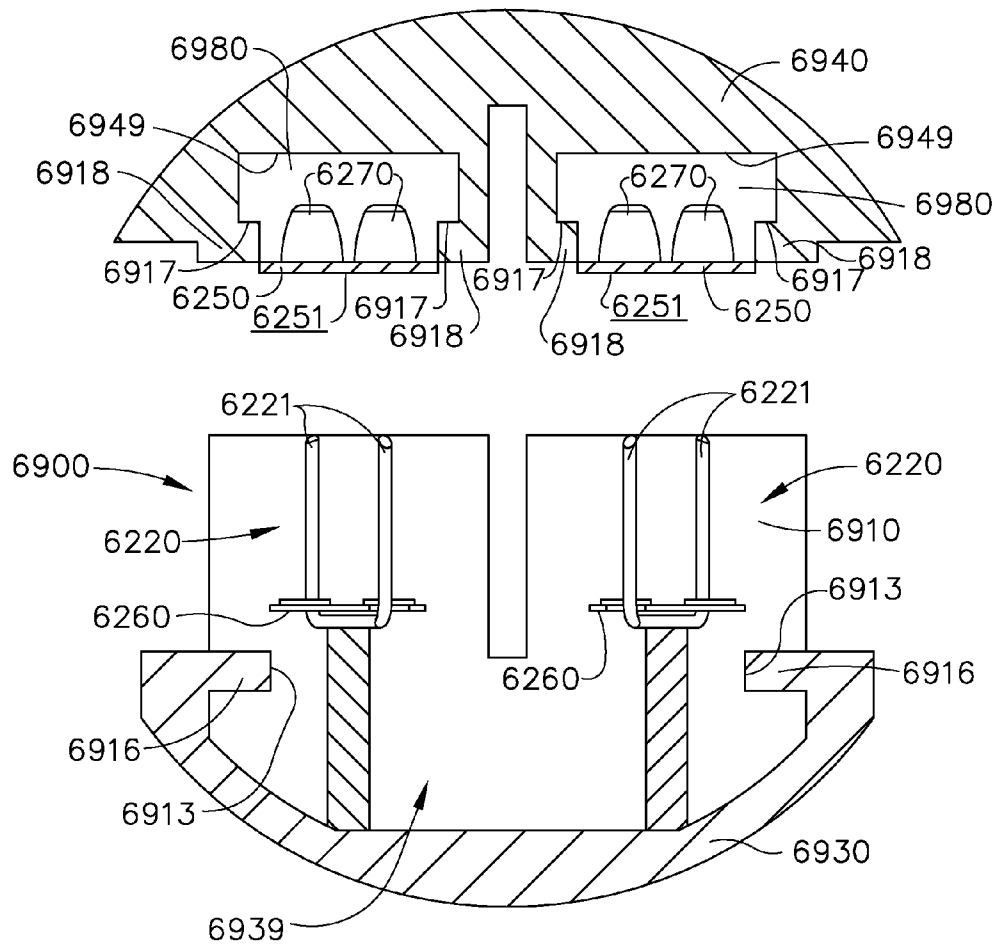


FIG. 225

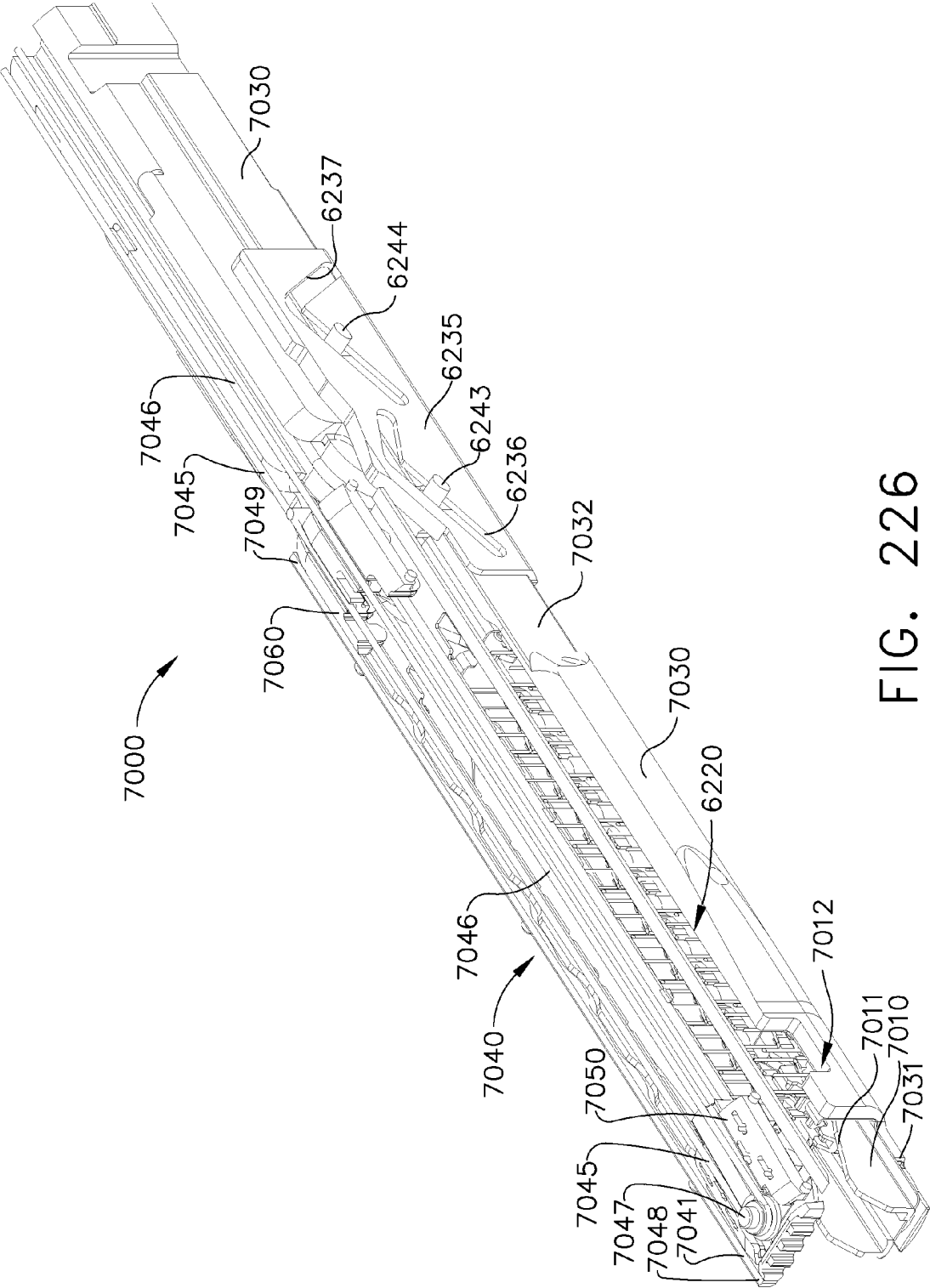


FIG. 226

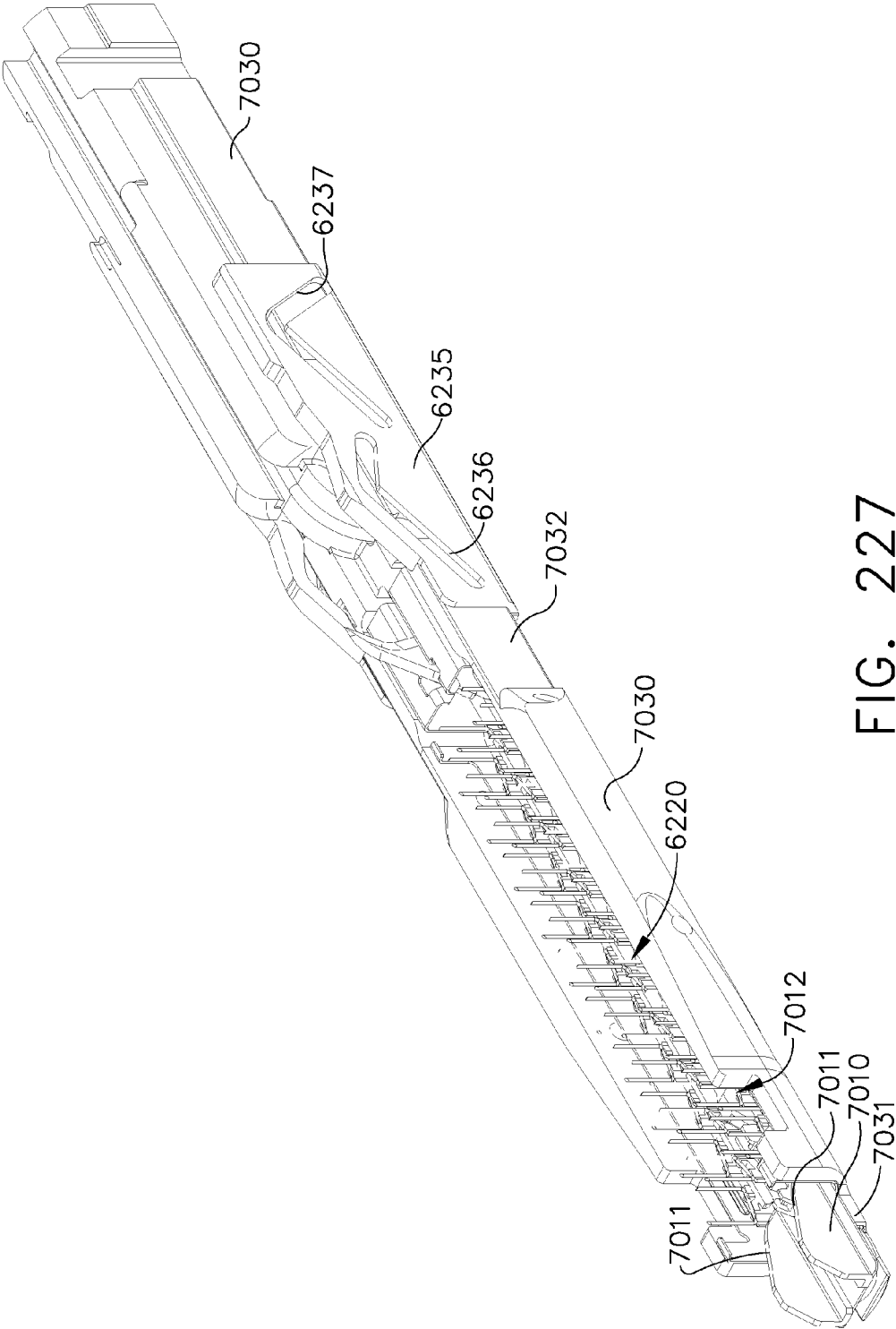


FIG. 227

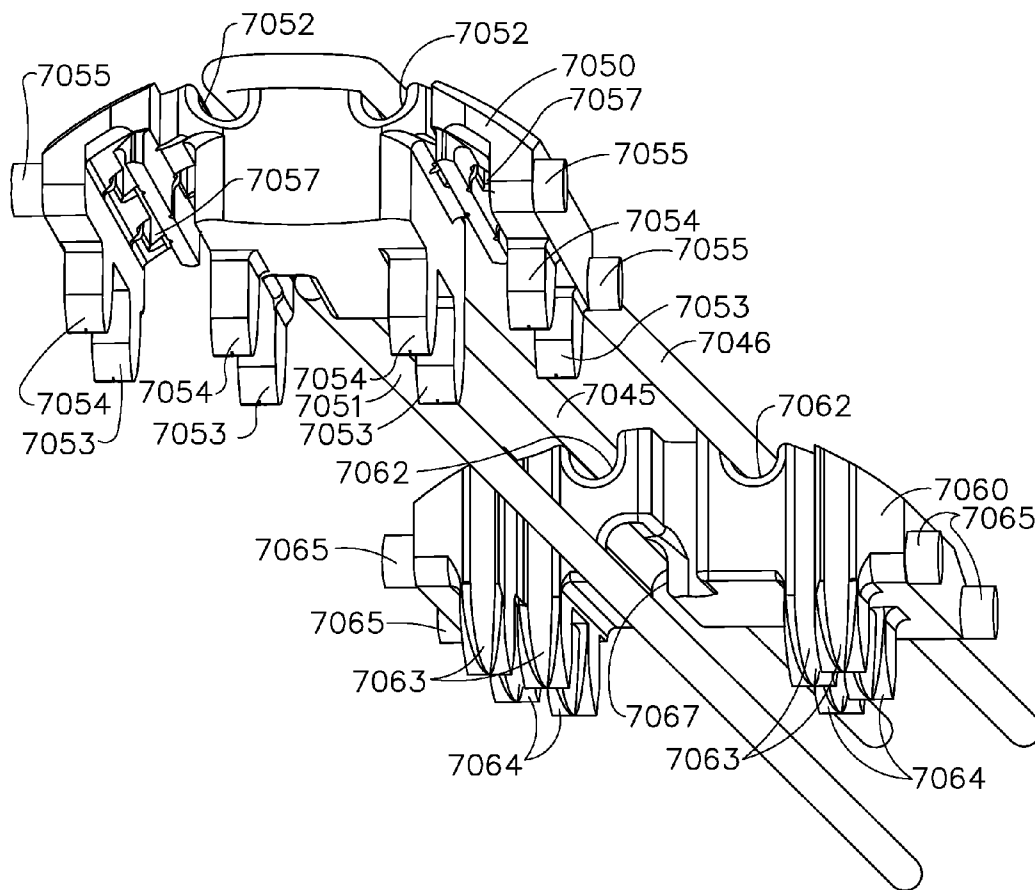


FIG. 228

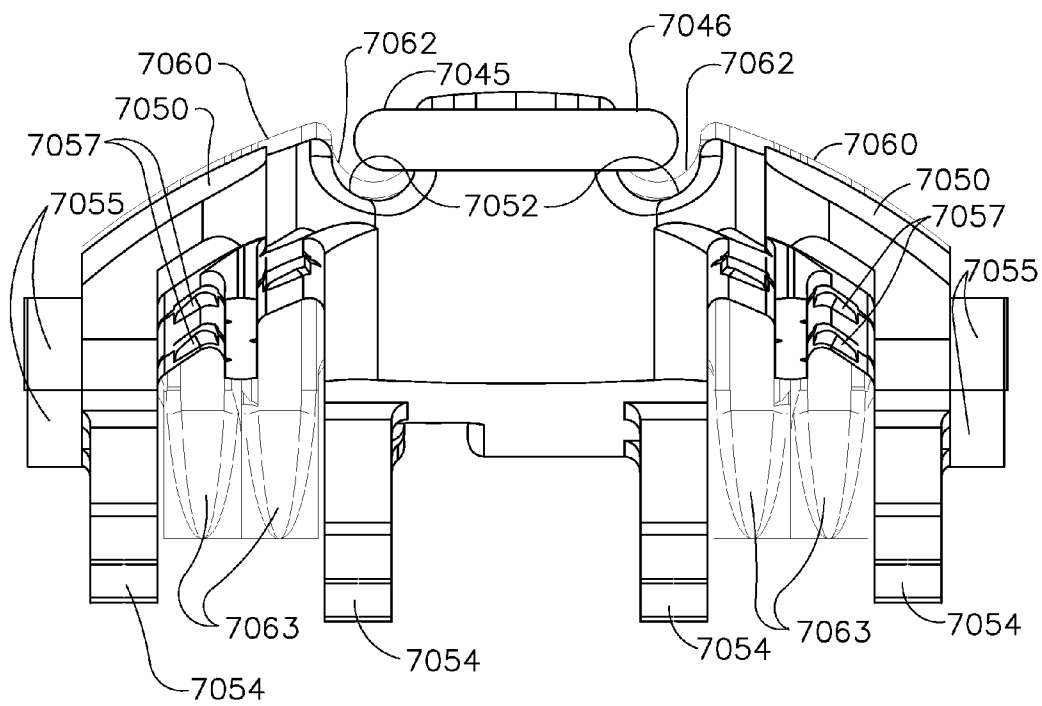


FIG. 229

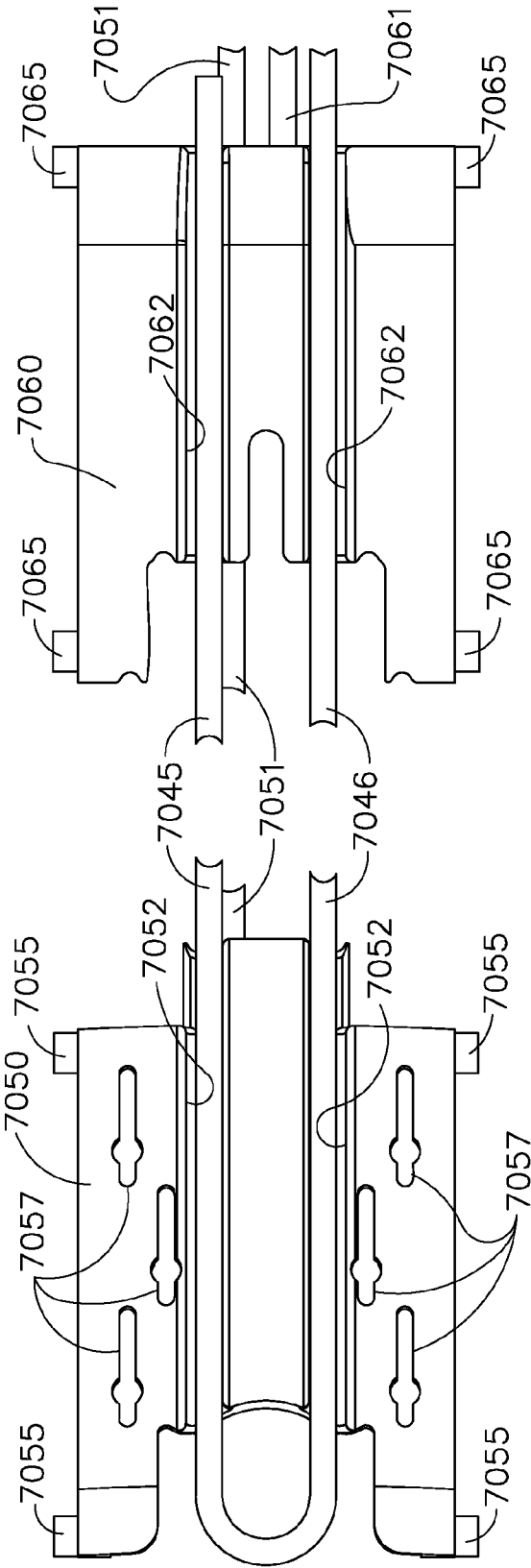


FIG. 230

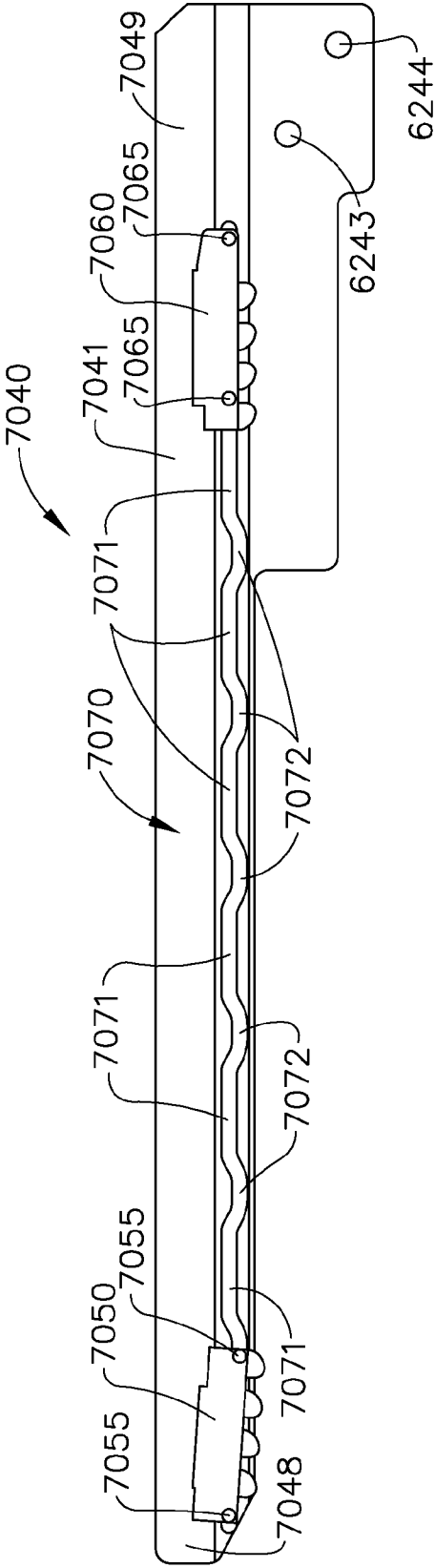


FIG. 231

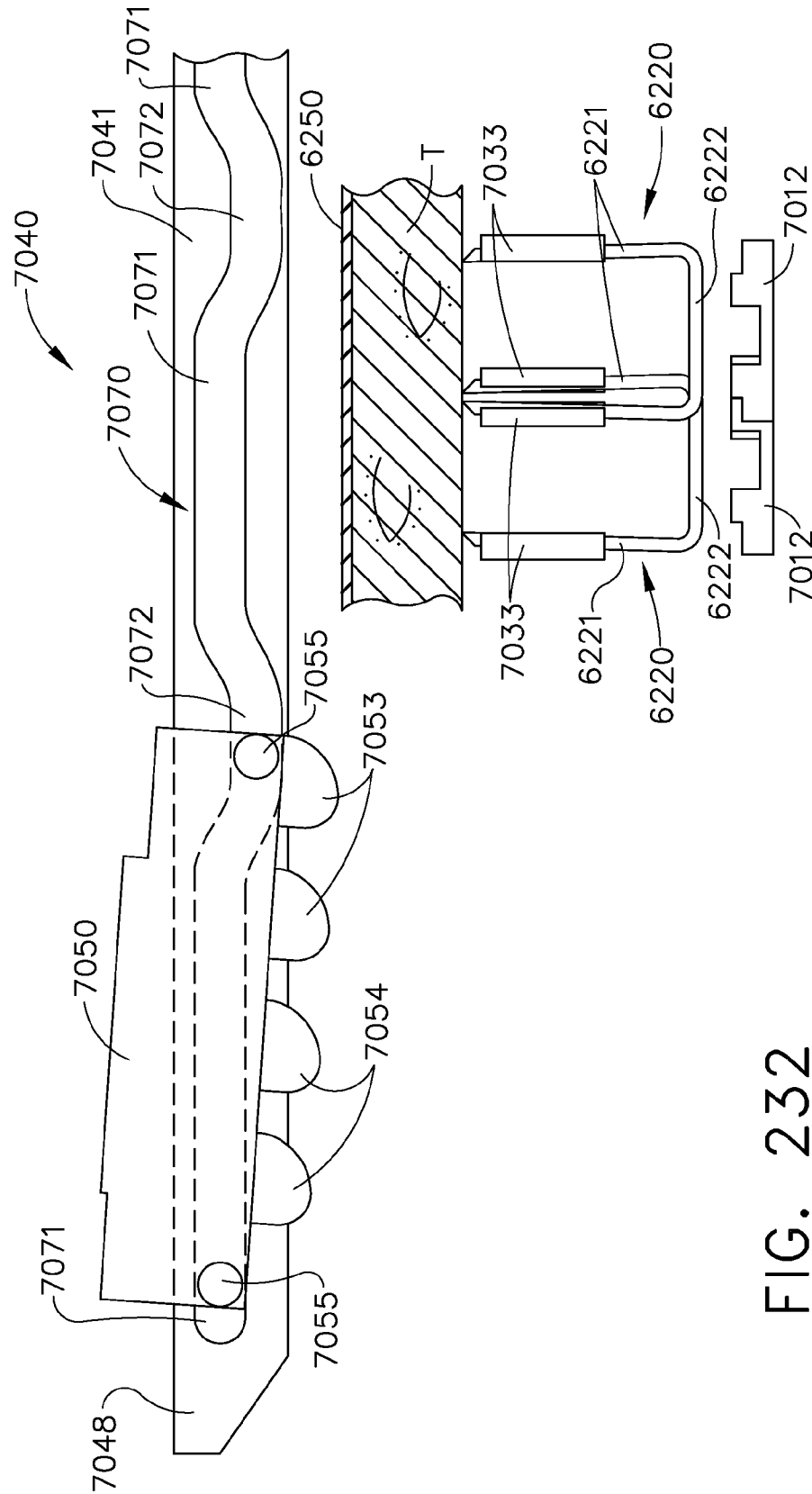


FIG. 232

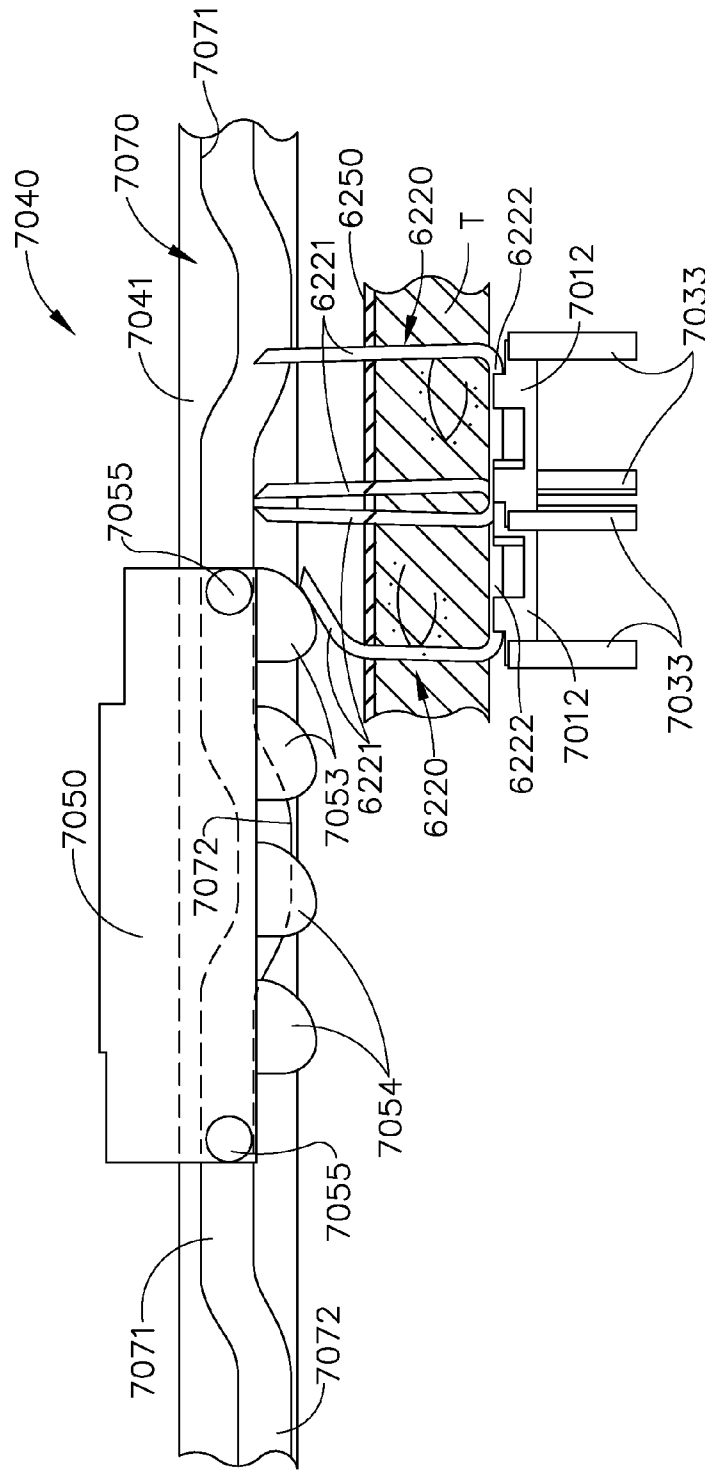
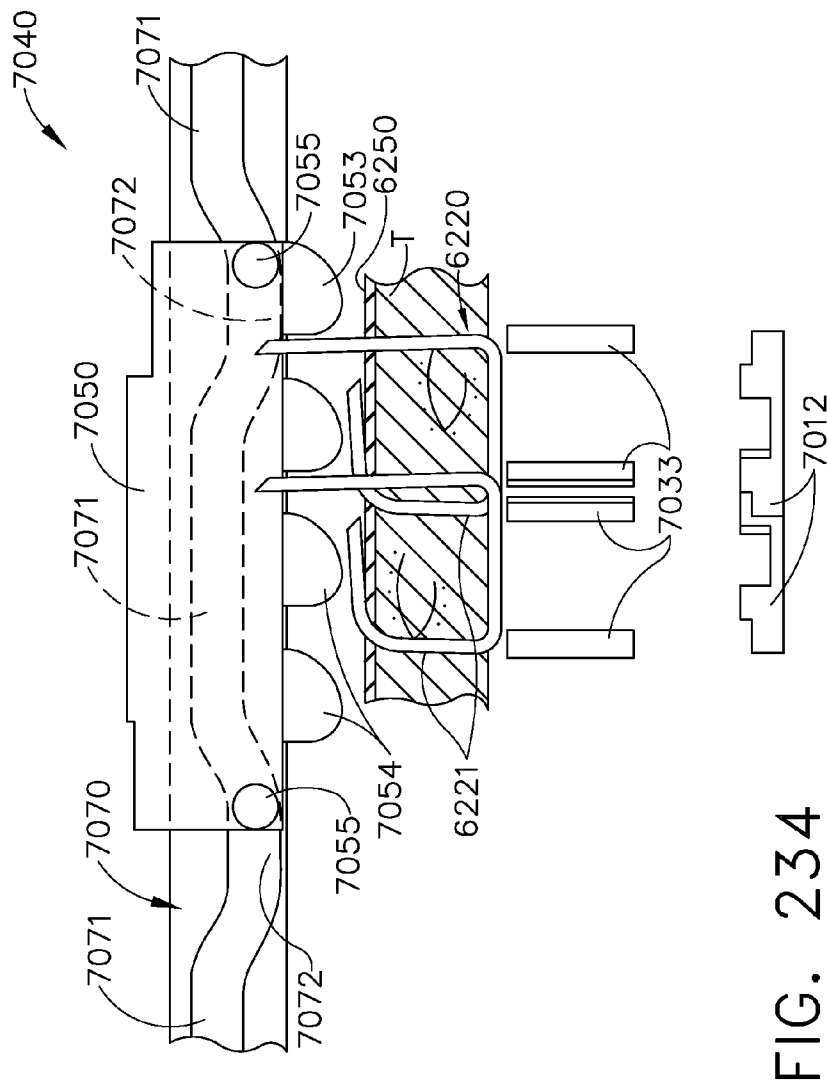


FIG. 233



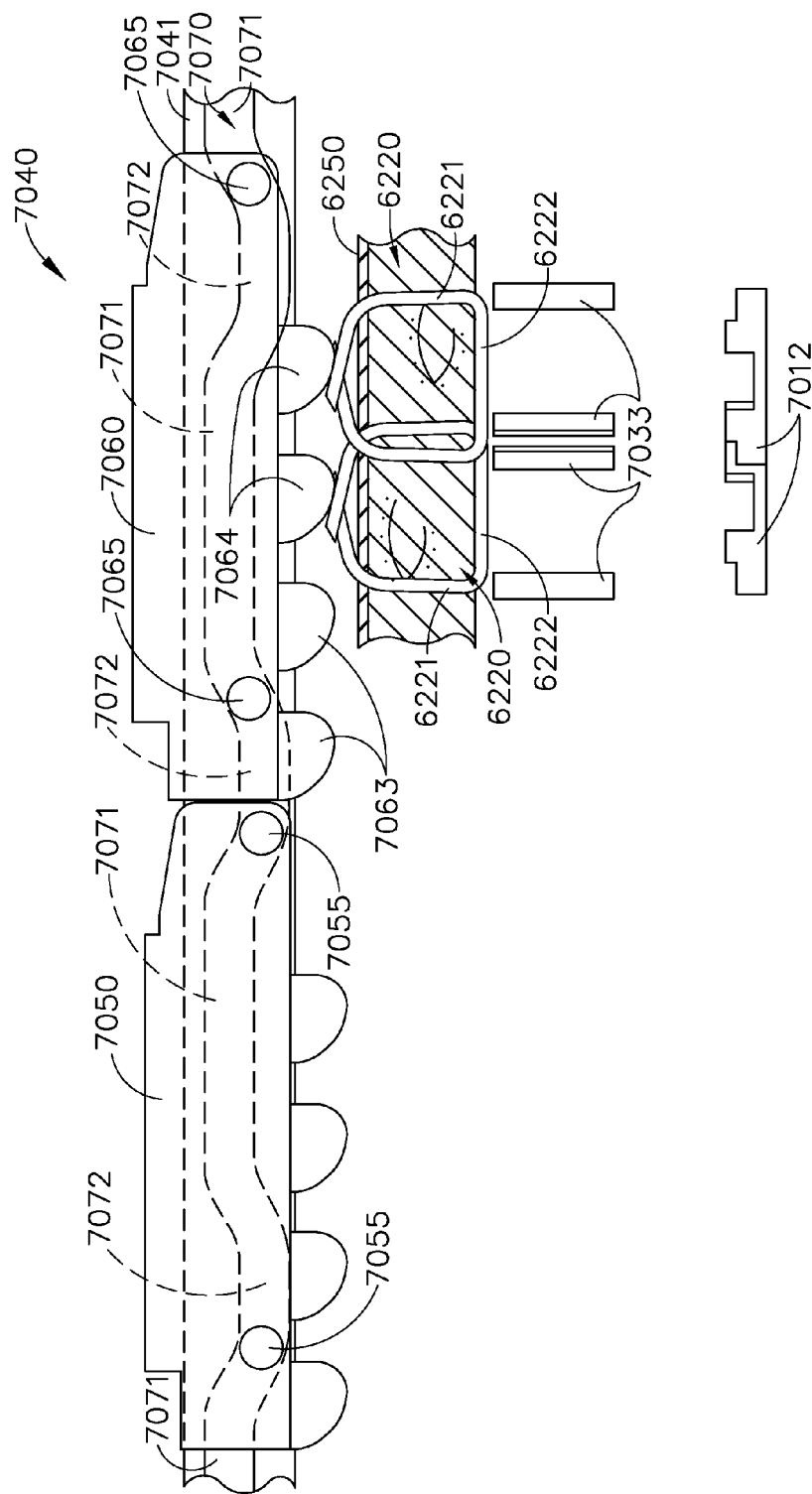


FIG. 235

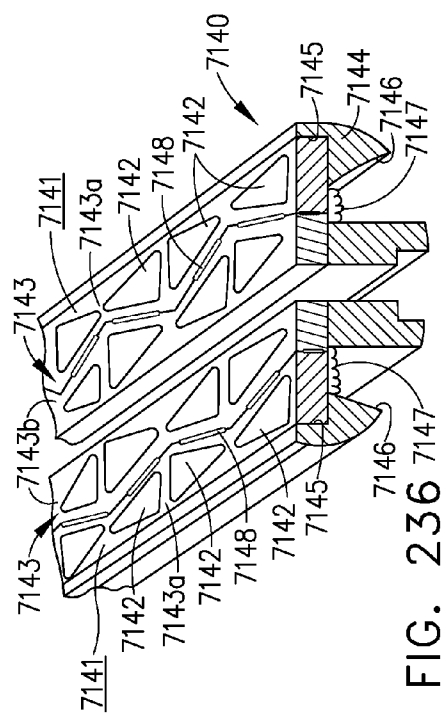


FIG. 237

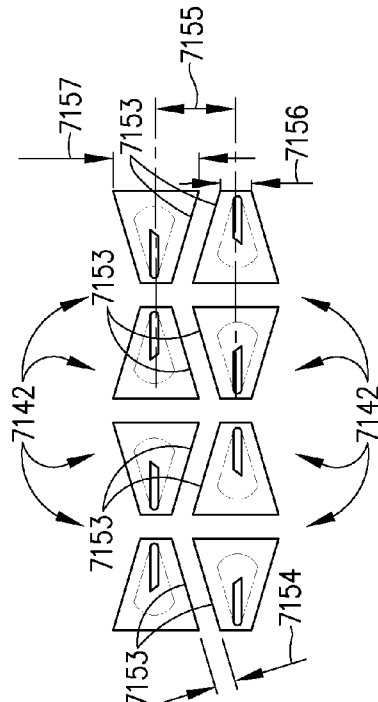
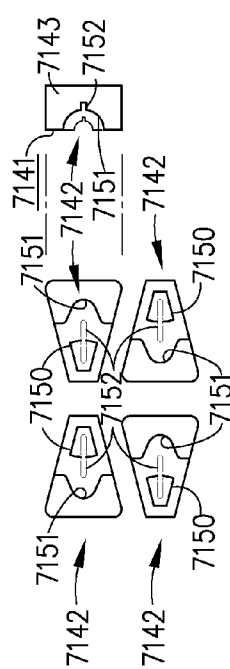
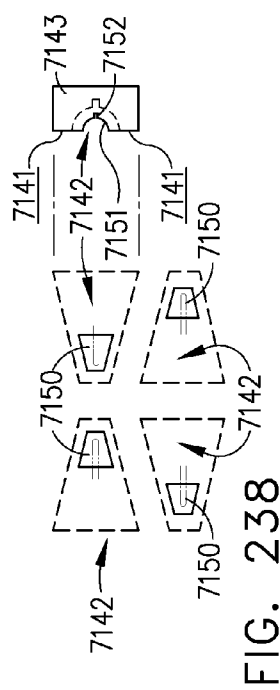
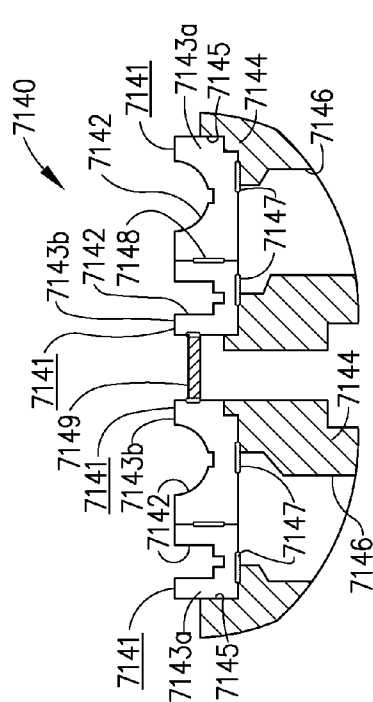


FIG. 240

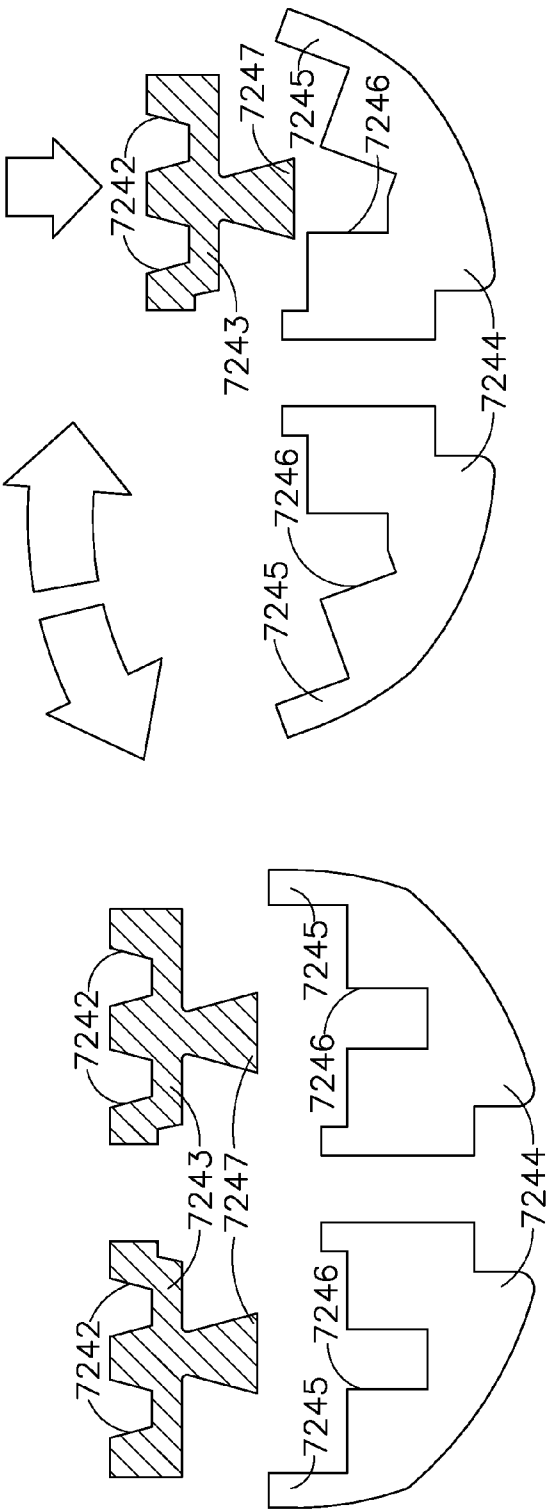


FIG. 241

FIG. 242

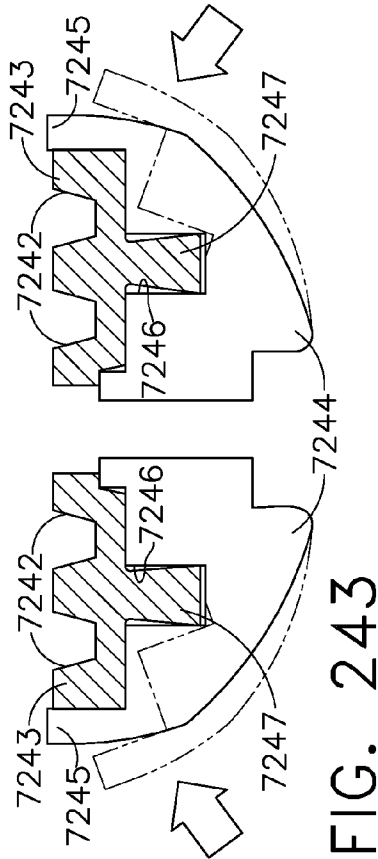


FIG. 243

1

SURGICAL INSTRUMENTS WITH RECONFIGURABLE SHAFT SEGMENTS

BACKGROUND

1. Technical Field

The present invention relates to surgical instruments and, in various embodiments, to surgical cutting and stapling instruments and staple cartridges therefor that are designed to cut and staple tissue.

2. Background

Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

In many endoscopic surgical applications, it is desirable to employ end effectors that are only as large as necessary to complete a particular surgical procedure. Smaller end effectors provide better visualization of the surgical site. Smaller end effectors also allow for better access and manipulation in tight spaces. Designers of such end effectors face many challenges when trying to develop small end effectors. The ability to manufacture small end effectors and, more particularly, small endocutters that are designed to cut and staple tissue is hampered by the magnitude of the actuation forces that are generally required to form lines of staples and cut tissue. Such actuation forces can also vary with the thickness and composition of the tissue being treated. For example, larger actuation forces are commonly required to cut and staple thick tissues. Whereas, the magnitude of the actuation forces required to cut and staple thinner tissues in general are smaller. Thus, many existing endocutters typically employ robust anvil closure systems and staple driving systems that are configured to accommodate a specific range of tissue thicknesses. Such devices, however, are often not well-suited for treating thinner tissues.

Prior endocutter devices also generally cut the tissue as the staples are driven and formed in the tissue on each side of the cut. While such devices are very effective for those procedures that require the tissue to be cut and fastened, they do not provide the surgeon with the option of installing fasteners without cutting tissue. Likewise, while various forms of articulating endocutters have been developed to improve access, the components generally employed in such devices must be substantial enough to accommodate structures that can generate and transmit sufficient firing and closure forces to the end effector from the handle of the device. Thus, such end effectors are often too large to effectively access tight spaces in the body.

Accordingly, there is a need for surgical cutting and stapling instruments and staple cartridge arrangements that address many of the challenges discussed above.

The foregoing discussion is intended only to illustrate some of the shortcomings present in the field of the invention at the time, and should not be taken as a disavowal of claim scope.

SUMMARY

In accordance with general aspects of at least one form, there is provided a surgical instrument that includes a handle

2

assembly that has a flexible spine assembly operably coupled thereto. An elongated shaft assembly is received on the flexible spine assembly and has a reconfigurable shaft segment that is selectively reconfigurable between a linear configuration wherein all portions of the reconfigurable shaft segment are substantially coaxially aligned with each other and configurations wherein at least one portion of the reconfigurable shaft segment is orientated in a non-linear orientation relative to at least one other portion of the reconfigurable shaft segment. The elongated shaft assembly further has a closure tube segment that is axially movable relative to the reconfigurable shaft segment in response to firing motions applied thereto from a firing system that is operably supported in the handle assembly. An end effector is coupled to the flexible spine assembly and has first and second jaw members that are movable relative to each other from an open position to closed positions in response to axial movement of the closure tube segment.

In accordance with other general aspects of at least one form, there is provided a surgical instrument that includes a handle assembly that has a flexible spine assembly operably coupled thereto. An elongated shaft assembly is received on the flexible spine assembly and is operably coupled to the handle assembly. In various embodiments, the elongated shaft assembly includes a reconfigurable shaft segment that comprises a plurality of movably interconnected tubular links. Each tubular link has a tubular body portion that has a spherically-shaped coupler formed on one end thereof. The spherically-shaped coupler has a passage therethrough that extends into a hollow spherical socket formed on another end thereof that is sized to rotatably receive a spherically-shaped coupler of another tubular link therein. A locking arrangement is provided on each tubular link for locking adjacent tubular links in a desired orientation relative to each other. In certain embodiments, the elongated shaft assembly further comprises a closure tube segment that is movably supported on a corresponding portion of the spine assembly for selective axial travel thereon in a distal direction away from the handle assembly and in a proximal direction towards the handle assembly. In at least some implementations, the surgical instrument further comprises a firing system that is operably supported by the handle assembly. The firing system interfaces with the closure tube segment to selectively cause the closure tube segment to axially move in the distal and proximal directions on the corresponding portion of the spine assembly. An end effector is coupled to the spine assembly and has first and second jaw members that are movable relative to each other from an open position to closed positions. The first jaw member is configured to support a staple cartridge therein. The first and second jaw members are configured to be moved between the open and closed positions in response to axial movement of the closure tube segment on the spine assembly.

In accordance with still other general aspects of at least one form, there is provided a surgical instrument that includes a handle assembly that has a flexible spine assembly operably coupled thereto. An elongated shaft assembly is received on the flexible spine assembly and is operably coupled to the handle assembly. In various embodiments, the elongated shaft assembly includes a reconfigurable shaft segment that comprises a plurality of movably interconnected tubular links. Each tubular link has a tubular body portion that has a spherically-shaped coupler formed on one end thereof. Each spherically-shaped coupler has a passage that extends there-through into a hollow spherical socket formed on another end thereof that is sized to rotatably receive a spherically-shaped coupler of another tubular link therein. At least one selec-

3

tively expandable locking bladder extends through the plurality of movably interconnected tubular links such that when each locking bladder is in an expanded condition, the tubular links are immovable relative to each other. In various implementations, the elongated shaft assembly further comprises a closure tube segment that is movably supported on a portion of the spine assembly for selective axial travel thereon in a distal direction away from the handle assembly and in a proximal direction towards the handle assembly. In at least some embodiments, the surgical instrument further comprises a firing system that is operably supported by the handle assembly. The firing system interfaces with the closure tube segment to selectively cause the closure tube segment to move on the corresponding portion of the flexible spine assembly. An end effector is coupled to the spine assembly. The end effector has first and second jaw members that are movable relative to each other from an open position to closed positions. The first and second jaw members are configured to be moved between the open and closed positions in response to axial movement of the closure tube segment.

BRIEF DESCRIPTION OF DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a cross-sectional view of a surgical instrument embodiment of the present invention;

FIG. 1A is a perspective view of one embodiment of an implantable staple cartridge of the present invention;

FIG. 1B-1E illustrate portions of an end effector of various embodiments of the present invention clamping and stapling tissue with an implantable staple cartridge embodiment of the present invention;

FIG. 2 is an exploded assembly view of an end effector embodiment and a portion of a surgical stapling instrument embodiment of the present invention shown in cross-section;

FIG. 3 is a side elevational view of an anvil embodiment of the present invention;

FIG. 4 is a cross-sectional view of a portion of the handle assembly depicted in FIG. 1;

FIG. 5 is a partial cross-sectional view of the handle assembly of FIG. 1 taken along line 5-5 in FIG. 1;

FIG. 6 is a perspective view of a portion of firing transmission embodiment of the present invention;

FIG. 7 is a partial cross-sectional view of the handle assembly of FIG. 1 taken along line 7-7 in FIG. 1;

FIG. 8 is a partial cross-sectional view of a portion of the handle assembly of FIG. 7 taken along line 8-8 in FIG. 7;

FIG. 9 is a cross-sectional view of a surgical instrument embodiment of the present invention after an end effector has been coupled to a spine portion of the surgical instrument and prior to being locked thereto;

FIG. 9A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 10;

FIG. 10 is a cross-sectional view of the surgical instrument of FIG. 9 after the end effector has been locked to the spine portion of the surgical instrument;

FIG. 10A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 10;

FIG. 11 is a cross-sectional view of the surgical instrument of FIGS. 9 and 10 after the first firing adapter has been advanced to the beginning of the clamping ramp portions of the anvil;

4

FIG. 11A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 11 with tissue received between the anvil and staple cartridge thereof;

FIG. 12 is a cross-sectional view of the surgical instrument of FIGS. 9-11 after the first firing adapter has been advanced over the clamping ramp portions of the anvil;

FIG. 12A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 12;

FIG. 13 is a cross-sectional view of the surgical instrument of FIGS. 9-12 after the first firing adapter has been advanced over the staple forming ramp to fully form the staples within the implantable staple cartridge;

FIG. 13A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 13;

FIG. 14 is a cross-sectional view of the surgical instrument of FIGS. 9-13 after the first firing adapter has been advanced over the staple forming ramp to fully form the staples within the implantable staple cartridge and after the knife bar has been longitudinally advanced through the end effector;

FIG. 14A is an enlarged view of the end effector and a portion of the surgical instrument of FIG. 14;

FIG. 15 is an exploded view of another end effector embodiment of the present invention with a portion of the spine member of a surgical instrument embodiment of the present invention shown in cross-section;

FIG. 16 is a partial cross-sectional view of the end effector embodiment of FIG. 15 in the open position and attached to the surgical instrument embodiment;

FIG. 17 is another partial cross-sectional view of the end effector embodiment of FIGS. 15 and 16 in the fully clamped position;

FIG. 18 is another partial cross-sectional view of the end effector embodiment of FIGS. 15-17 in the fully fired position and prior to advancement of the distal knife member;

FIG. 19 is another partial cross-sectional view of the end effector embodiment of FIGS. 15-18 in the fully fired position and after complete advancement of the distal knife member;

FIG. 20 is a cross-sectional view of a portion of another handle assembly embodiment of the present invention;

FIG. 21 is a partial cross-sectional view of a portion of the handle assembly of FIG. 20 taken along line 21-21 in FIG. 20;

FIG. 22 is a partial cross-sectional view of a portion of the handle assembly of FIG. 20 taken along line 22-22 in FIG. 20;

FIG. 23 is a partial cross-sectional view of a portion of the handle assembly of FIG. 20 taken along line 23-23 in FIG. 20;

FIG. 24 is a cross-sectional view of a portion of another handle assembly embodiment of the present invention;

FIG. 25 is a partial cross-sectional side view of another end effector embodiment of the present invention coupled to a portion of a surgical instrument embodiment of the present invention with the end effector supporting a surgical staple cartridge embodiment of the present invention and with the anvil thereof in an open position;

FIG. 26 is another partial cross-sectional side view of the end effector of FIG. 25 in a closed position;

FIG. 27 is another partial cross-sectional side view of the end effector of FIGS. 25 and 26 as the knife bar is starting to advance through the end effector;

FIG. 28 is another partial cross-sectional side view of the end effector of FIGS. 25-27 with the knife bar partially advanced therethrough;

FIG. 29 is a partial cross-sectional side view of another end effector embodiment of the present invention coupled to a portion of a surgical instrument embodiment of the present invention with the end effector supporting another surgical staple cartridge embodiment of the present invention and with the anvil thereof in an open position;

5

FIG. 30 is another partial cross-sectional side view of the end effector of FIG. 29 with the knife bar partially advanced therethrough;

FIG. 31 is a cross-sectional view of another surgical instrument embodiment of the present invention with the anvil of the end effector thereof in an open position;

FIG. 32 is an exploded assembly view of the end effector embodiment and a portion of the surgical stapling instrument embodiment of FIG. 31 shown in cross-section;

FIG. 33 is a top view of the end effector and a portion of the elongated shaft assembly of the surgical instrument of FIG. 31 with portions thereof shown in cross-section taken along line 33-33 in FIG. 31;

FIG. 34 is a top view of the end effector and a portion of the elongated shaft assembly of the surgical instrument of FIG. 31 with portions thereof shown in cross-section;

FIG. 35 is another top view of the end effector and a portion of the elongated shaft assembly of the surgical instrument of FIG. 31 with the end effector in articulated orientation and with the end effector in an open position;

FIG. 36 is another top view of the end effector of FIG. 35 with the end effector in a closed or clamped position;

FIG. 37 is an enlarged view of a portion of the end effector and surgical instrument embodiment depicted in FIG. 36;

FIG. 38 is a cross-sectional view of a portion of the handle assembly of the surgical instrument of FIG. 31;

FIG. 39 is another cross-sectional view of the portion of the handle assembly of FIG. 38 taken along line 39-39 in FIG. 38;

FIG. 40 is a partial perspective exploded view of an articulation ball and socket arrangement of various embodiments of the present invention;

FIG. 41 is a top view of an end effector and a portion of an elongated shaft assembly of another surgical instrument embodiment of the present invention in an unarticulated orientation;

FIG. 42 is another top view of the end effector and portion of elongated shaft assembly of FIG. 41 in an articulated position;

FIG. 43 is cross-sectional view of another surgical instrument embodiment of the present invention;

FIG. 44 is partial cross-sectional view of a portion of the articulated shaft assembly of the surgical instrument embodiment of FIG. 43;

FIG. 44A is a cross-sectional view of a portion of the articulated shaft assembly of FIG. 44;

FIG. 44B is another cross-sectional view of another portion of the articulated shaft assembly of FIG. 44;

FIG. 44C is another cross-sectional view of another portion of the articulated shaft assembly of FIG. 44;

FIG. 44D is another cross-sectional view of another portion of the articulated shaft assembly of FIG. 44;

FIG. 44E is another cross-sectional view of another portion of the articulated shaft assembly of FIG. 44;

FIG. 44F is another cross-sectional view of another portion of the articulated shaft assembly of FIG. 44;

FIG. 45 is a partial cross-sectional view of the articulated shaft assembly of FIG. 44 taken along line 45-45 in FIG. 44;

FIG. 46 is a partial cross-sectional view of the articulated shaft assembly of FIG. 44 taken along line 46-46 in FIG. 44;

FIG. 47 is another cross-sectional view of the surgical instrument of FIG. 43 with the end effector thereof shown in a fully articulated position;

FIG. 48 is a cross-sectional view of the end effector of FIG. 47 with a bellows-like cover extending over the articulation joint;

6

FIG. 49 is a cross-section view of a handle assembly of another surgical instrument embodiment of the present invention;

FIG. 50 is a cross-sectional exploded assembly view of an end effector and the distal end of the elongated shaft assembly of FIG. 49;

FIG. 51 is another cross-sectional view of the end effector and portion of elongated shaft assembly of FIG. 50 with the end effector in an open position;

FIG. 52 is another cross-sectional view of the end effector and portion of the elongated shaft assembly with the end effector in a closed position;

FIG. 53 is another cross-sectional view of the end effector and portion of the elongated shaft of FIGS. 49-52 with the knife member in a fully fired position;

FIG. 54 is a perspective view of the end effector of FIGS. 51-53 in an open position;

FIG. 55 is a cross-sectional view of the end effector of FIGS. 51-54 taken along line 55-55 in FIG. 51;

FIG. 56 is a partial perspective view of an elongated shaft assembly of another embodiment of the present invention attached to an end effector embodiment of the present invention;

FIG. 57 is a partial cross-sectional view of a handle assembly of another surgical instrument embodiment of the present invention;

FIG. 58 is a cross-sectional view of a portion of the elongated shaft assembly of FIGS. 56 and 57 taken along line 58-58 in FIG. 57;

FIG. 59 is an enlarged view of a portion of the handle assembly of FIG. 57;

FIG. 60 is a cross-sectional view of a distal end portion of the elongated shaft assembly of FIGS. 56-59;

FIG. 61 is a partial perspective view of an elongated shaft assembly of another embodiment of the present invention attached to an end effector embodiment of the present invention;

FIG. 62 is a cross-sectional view of a portion of a reconfigurable shaft segment of the elongated shaft of FIG. 61;

FIG. 63 is a partial perspective view of an elongated shaft assembly of another embodiment of the present invention attached to an end effector embodiment of the present invention;

FIG. 64 is a cross-sectional view of a handle assembly of another surgical instrument embodiment of the present invention;

FIG. 65 is a cross-sectional view of a portion of the elongated shaft assembly of FIGS. 63 and 64 taken along line 65-65 in FIG. 64;

FIG. 66 is an enlarged view of a portion of the handle assembly of FIG. 64;

FIG. 67 is a cross-sectional view of a portion of the reconfigurable shaft segment depicted in FIG. 63 with the tubular link portions thereof aligned in a substantially straight line;

FIG. 68 is a cross-sectional view of a portion of the reconfigurable shaft segment depicted in FIGS. 63 and 67 with the tubular link portions thereof aligned in a substantially curved (non-coaxial) orientation;

FIG. 69 is a perspective view of an alternative staple cartridge embodiment of the present invention installed in a surgical cutting and stapling device embodiment of the present invention;

FIG. 70 is a top view of the surgical staple cartridge and elongated channel of the device depicted in FIG. 69;

7

FIG. 71 is a top view of another surgical staple cartridge embodiment of the present invention installed in an elongated channel of an end effector embodiment of the present invention;

FIG. 72 is a bottom view of an anvil embodiment of the present invention;

FIG. 73 is a partial perspective view of a plurality of staples forming a portion of a staple line embodiment of the present invention;

FIG. 74 is another partial perspective view of the staple line embodiment of FIG. 73 with the staples thereof after being formed by being contacted by the anvil of the surgical cutting and stapling device;

FIG. 75 is a partial perspective view of alternative staples forming a portion of another staple line embodiment of the present invention;

FIG. 76 is a partial perspective view of alternative staples forming a portion of another staple line embodiment of the present invention;

FIG. 77 is a partial perspective view of alternative staples forming a portion of another staple line embodiment of the present invention;

FIG. 78 is a cross-sectional view of an end effectors embodiment of the present invention supporting a staple cartridge embodiment of the present invention;

FIG. 79 is a cross-sectional view of the elongated channel portion of the end effector of FIG. 78 after the implantable staple cartridge body portion and staples have been removed therefrom;

FIG. 80 is a cross-sectional view of an end effectors embodiment of the present invention supporting another staple cartridge embodiment of the present invention;

FIG. 81 is a partial cross-sectional view of a surgical stapling instrument embodiment of the present invention with a staple cartridge supported in the end effector thereof to move the cartridge locking system to an unlocked position;

FIG. 82 is another partial cross-sectional view of the surgical stapling instrument of FIG. 81 with the staple cartridge being removed from the end effector and the cartridge locking system in a locked position;

FIGS. 83A-83D diagram the deformation of a surgical staple positioned within a collapsible staple cartridge body in accordance with at least one embodiment;

FIG. 84A is a diagram illustrating a staple positioned in a crushable staple cartridge body;

FIG. 84B is a diagram illustrating the crushable staple cartridge body of FIG. 84A being crushed by an anvil;

FIG. 84C is a diagram illustrating the crushable staple cartridge body of FIG. 84A being further crushed by the anvil;

FIG. 84D is a diagram illustrating the staple of FIG. 84A in a fully formed configuration and the crushable staple cartridge of FIG. 84A in a fully crushed condition;

FIG. 85 is a diagram depicting a staple positioned against a staple cartridge support surface and illustrating potential relative movement therebetween;

FIG. 86 is a cross-sectional view of a staple cartridge support surface comprising a slot, or trough, configured to stabilize the base of the staple of FIG. 85;

FIG. 87 is a cross-sectional view of a staple comprising an overmolded crown and a slot, or trough, configured to receive a portion of the crown in accordance with at least one alternative embodiment;

FIG. 88 is a top view of a staple cartridge in accordance with at least one embodiment comprising staples embedded in a collapsible staple cartridge body;

FIG. 89 is an elevational view of the staple cartridge of FIG. 88;

8

FIG. 90 is an elevational view of a staple cartridge in accordance with at least one embodiment comprising a protective layer surrounding staples positioned within a collapsible staple cartridge body;

FIG. 91 is a cross-sectional view of the staple cartridge of FIG. 90 taken along line 91-91 in FIG. 90;

FIG. 92 is an elevational view of a staple cartridge in accordance with at least one embodiment comprising staples at least partially extending outside of a collapsible staple cartridge body and a protective layer surrounding the staple cartridge body;

FIG. 93 is a cross-sectional view of the staple cartridge of FIG. 92 taken along line 93-93 in FIG. 92;

FIG. 94 is a partial break-away view of a staple cartridge in accordance with at least one embodiment comprising staples at least partially embedded in a collapsible staple cartridge body, the staples being at least partially positioned in a staple cavity void in the staple cartridge body;

FIG. 95 is a cross-sectional view of the staple cartridge of FIG. 94 taken along line 95-95 in FIG. 94;

FIG. 96 is a partial break-away view of a staple cartridge in accordance with at least one embodiment;

FIG. 97 is a partial break-away view of a staple cartridge in accordance with at least one embodiment comprising staples at least partially embedded within a collapsible staple cartridge body and an alignment matrix connecting the staples and aligning the staples with respect to each other;

FIG. 98 is a cross-sectional view of the staple cartridge of FIG. 97 taken along line 98-98 in FIG. 97;

FIG. 99 is partial cut-away view of an inner layer of a compressible staple cartridge body;

FIG. 100 is a diagram illustrating the inner layer of FIG. 99 compressed between a transfer plate and a support plate;

FIG. 101 is a diagram illustrating staples being inserted into the compressed inner layer of FIG. 100;

FIG. 102 is a diagram of the support plate of FIG. 100 being removed away from the inner layer;

FIG. 103 is a diagram of a subassembly comprising the inner layer of FIG. 99 and the staples of FIG. 101 being inserted into an outer layer;

FIG. 104 is a diagram illustrating the outer layer of FIG. 103 being sealed to form a sealed staple cartridge;

FIG. 105 is a cross-sectional view of the sealed staple cartridge of FIG. 104;

FIG. 106 is a cross-sectional view of a staple cartridge and staple cartridge channel in accordance with at least one embodiment;

FIG. 107 is a diagram illustrating a portion of the staple cartridge of FIG. 106 in a deformed state;

FIG. 108 is an elevational view of an end effector of a surgical stapler comprising an anvil in an open position and a staple cartridge positioned within a staple cartridge channel;

FIG. 109 is an elevational view of the end effector of FIG. 108 illustrating the anvil in a closed position and the staple cartridge compressed between the anvil and the staple cartridge channel;

FIG. 110 is an elevational view of the end effector of FIG. 108 illustrating the staple cartridge of FIG. 108 positioned within the staple cartridge channel in an alternative manner;

FIG. 111 is a cross-sectional view of an end effector of a surgical stapler comprising a compressible staple cartridge positioned within a staple cartridge channel and a piece of buttress material attached to an anvil;

FIG. 112 is a cross-sectional view of the end effector of FIG. 111 illustrating the anvil in a closed position;

FIG. 113 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge comprising a water impermeable layer;

FIG. 114 is a cross-sectional view of another alternative embodiment of an end effector of a surgical stapler;

FIG. 115 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a stepped anvil and a staple cartridge comprising a stepped cartridge body;

FIG. 116 is a cross-sectional view of another alternative embodiment of an end effector of a surgical stapler;

FIG. 117 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising inclined tissue-contacting surfaces;

FIG. 118 is a cross-sectional view of another alternative embodiment of an end effector of a surgical stapler comprising inclined tissue-contacting surfaces;

FIG. 119 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a support insert configured to support a staple cartridge;

FIG. 120 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge comprising a plurality of compressible layers;

FIG. 121 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge comprising a stepped compressible cartridge body;

FIG. 122 is a cross-sectional view of another alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge comprising a stepped compressible cartridge body;

FIG. 123 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge comprising a curved tissue-contacting surface;

FIG. 124 is a cross-sectional view of an alternative embodiment of an end effector of a surgical stapler comprising a staple cartridge having an inclined tissue-contacting surface;

FIG. 125 is a cross-sectional view of a compressible staple cartridge comprising staples and at least one medicament stored therein;

FIG. 126 is a diagram illustrating the compressible staple cartridge of FIG. 125 after it has been compressed and the staples contained therein have been deformed;

FIG. 127 is a partial cut-away view of a staple cartridge in accordance with at least one embodiment;

FIG. 128 is a cross-sectional view of the staple cartridge of FIG. 127;

FIG. 129 is a perspective view of an implanted staple cartridge in accordance with at least one alternative embodiment;

FIG. 130 is a cross-sectional view of the implanted staple cartridge of FIG. 129;

FIG. 131 is a perspective view of an alternative embodiment of a staple cartridge comprising deformable members extending from an outer layer of the staple cartridge;

FIG. 132 is a perspective view of an alternative embodiment of a staple cartridge comprising an outer layer of the staple cartridge being assembled to an inner layer;

FIG. 133 is a cross-sectional view of an alternative embodiment of a staple cartridge comprising a plurality of staples, a compressible layer, and a pledget layer;

FIG. 134 is a perspective view of the pledget layer of FIG. 133;

FIG. 135 is a perspective view of a pledget singulated from the pledget layer of FIG. 133 and a staple aligned with a groove in the pledget;

FIG. 136 is a perspective view of two connected pledgets from the pledget layer of FIG. 133;

FIG. 137 is a perspective view of a pledget support frame of the pledget layer of FIG. 133 being removed from the singulated pledgets;

FIG. 138 is an exploded perspective view of an alternative embodiment of a compressible staple cartridge comprising staples therein and a system for driving the staples against an anvil;

FIG. 138A is a partial cut-away view of an alternative embodiment of the staple cartridge of FIG. 138;

FIG. 139 is a cross-sectional view of the staple cartridge of FIG. 138;

FIG. 140 is an elevational view of a sled configured to traverse the staple cartridge of FIG. 138 and move the staples toward the anvil;

FIG. 141 is a diagram of a staple driver which can be lifted toward the anvil by the sled of FIG. 140;

FIG. 142 is a break-away view of a staple cartridge in accordance with at least one alternative embodiment comprising staples positioned within staple drivers;

FIG. 143 is a cross-sectional view of the staple cartridge of FIG. 142 positioned within a staple cartridge channel;

FIG. 144 is a cross-sectional view of the staple cartridge of FIG. 142 illustrating an anvil moved into a closed position and staples contained within the staple cartridge deformed by the anvil;

FIG. 145 is a cross-sectional view of the staple cartridge of FIG. 142 illustrating the staples moved upwardly toward the anvil;

FIG. 146 is a perspective view of an alternative embodiment of a staple cartridge comprising straps connecting the flexible sides of the staple cartridge;

FIG. 147 is a perspective view of a sled and cutting member assembly;

FIG. 148 is a diagram of the sled and cutting member assembly of FIG. 147 being used to lift the staples of the staple cartridge of FIG. 142;

FIG. 149 is a diagram illustrating a sled configured to engage and lift staples toward an anvil and a lock-out system configured to selectively permit the sled to move distally;

FIGS. 150A-150C illustrate the progression of a staple being inserted into a staple crown;

FIG. 151 is a cross-sectional view of a staple cartridge comprising a support pan or retainer;

FIG. 152 is a partial cross-sectional view of a compressible staple cartridge in accordance with at least one alternative embodiment;

FIG. 153 is a diagram illustrating the staple cartridge of FIG. 152 in an implanted condition;

FIG. 154 is a partial cut-away view of a compressible staple cartridge in accordance with at least one alternative embodiment;

FIG. 155 is a partial cross-sectional view of the staple cartridge of FIG. 154;

FIG. 156 is a diagram illustrating the staple cartridge of FIG. 154 in an implanted condition;

FIG. 157 is a partial cross-sectional view of a crushable staple cartridge in accordance with at least one alternative embodiment;

FIG. 158 is a partial cut-away view of a collapsible staple cartridge in accordance with at least one embodiment comprising a plurality of collapsible elements;

11

FIG. 159 is a perspective view of a collapsible element of FIG. 158 in an uncollapsed state;

FIG. 160 is a perspective view of the collapsible element of FIG. 159 in a collapsed state;

FIG. 161A is a partial cross-sectional view of an end effector of a surgical stapling instrument comprising a jaw, a staple cartridge channel positioned opposite the jaw, and a staple cartridge positioned within the staple cartridge channel, wherein the jaw comprises a retention matrix attached thereto;

FIG. 161B is a partial cross-sectional view of the end effector of FIG. 161A illustrating the jaw being moved toward the staple cartridge channel, the staple cartridge being compressed by the anvil and the retention matrix, and a staple at least partially extending through tissue positioned intermediate the retention matrix and the staple cartridge;

FIG. 161C is a partial cross-sectional view of the end effector of FIG. 161A illustrating the jaw in a final position and the retention matrix engaged with the staple of FIG. 161B;

FIG. 161D is a partial cross-sectional view of the end effector of FIG. 161A illustrating the jaw and the staple cartridge channel being moved away from the implanted staple cartridge and retention matrix;

FIG. 162 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising a plurality of retention members configured to engage a fastener leg extending therethrough;

FIG. 163 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising six retention members;

FIG. 164 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising eight retention members;

FIG. 165 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising a plurality of retention members configured to engage a fastener leg extending therethrough;

FIG. 166 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising six retention members;

FIG. 167 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising eight retention members;

FIG. 168 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising a plurality of retention members that have been stamped from a sheet of metal;

FIG. 169 is a perspective view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment comprising a plurality of apertures extending around the perimeter of the retention aperture;

FIG. 170 is a top view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment;

FIG. 171 is a top view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment;

FIG. 172 is a top view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment;

FIG. 173 is a top view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment;

FIG. 174 is a top view of a retention aperture of a retention matrix in accordance with at least one alternative embodiment;

12

FIG. 175 is a top view of a retention aperture of a retention matrix comprising a retention tab extending into the retention aperture in accordance with at least one embodiment;

FIG. 176 is a top view of a retention aperture of a retention matrix comprising a retention tab extending into the retention aperture in accordance with at least one alternative embodiment;

FIG. 177 is a perspective view of a fastening system comprising a plurality of staples, a retention matrix engaged with the staples, and an alignment matrix configured to align the staples;

FIG. 178 is a perspective view of the retention matrix of FIG. 177;

FIG. 179 is a perspective view of the alignment matrix of FIG. 177;

FIG. 180 is a partial top view of the retention matrix of FIG. 177 engaged with the staples of FIG. 177;

FIG. 181 is a partial bottom view of the retention matrix of FIG. 177 engaged with the staples of FIG. 177;

FIG. 182 is a partial elevational view of the fastening system of FIG. 177;

FIG. 183 is a partial perspective view of the fastening system of FIG. 177;

FIG. 184 is a partial cross-sectional view of the retention matrix of FIG. 177 engaged with the staples of FIG. 177;

FIG. 185 is a partial cross-sectional view of the fastening system of FIG. 177;

FIG. 186 is a perspective view of the fastening system of FIG. 177 further comprising protective caps assembled to the legs of the staples;

FIG. 187 is a bottom perspective view of the fastening system arrangement of FIG. 186;

FIG. 188 is a partial perspective view of the fastening system arrangement of FIG. 186;

FIG. 189 is a partial cross-sectional view of the fastening system arrangement of FIG. 186;

FIG. 190 is an elevational view of an end effector in accordance with at least one embodiment comprising a jaw in an open position, a retention matrix and a plurality of protective caps positioned in the jaw, and a staple cartridge positioned in a staple cartridge channel;

FIG. 191 is an elevational view of the end effector of FIG. 190 in a closed position;

FIG. 192 is an elevational view of the end effector of FIG. 190 in a fired position;

FIG. 193 is an elevational view of the retention matrix and protective caps of FIG. 190 assembled to the staple cartridge of FIG. 190;

FIG. 194 is a detail view of the arrangement of FIG. 193;

FIG. 195 is an elevational view of the end effector of FIG. 190 illustrating the jaw in an open position with thinner tissue positioned between the retention matrix and the staple cartridge;

FIG. 196 is an elevational view of the end effector of FIG. 190 illustrating the jaw in a closed position against the thinner tissue of FIG. 195;

FIG. 197 is an elevational view of the end effector of FIG. 190 illustrating the jaw in a fired position to capture the thinner tissue of FIG. 195 between the retention matrix and the staple cartridge;

FIG. 198 is an elevational view of the retention matrix and the protective caps of FIG. 190 assembled to the staple cartridge of FIG. 190 with the thin tissue of FIG. 195 positioned therebetween;

FIG. 199 is a detail view of the arrangement of FIG. 198;

13

FIG. 200 is a cross-sectional view of a protective cap positioned on the tip of a staple leg in accordance with at least one alternative embodiment;

FIG. 201 is a perspective view of a plurality of protective caps embedded within a sheet of material;

FIG. 202 is a perspective view of a jaw comprising a plurality of recesses configured to receive a plurality of protective caps therein;

FIG. 203 is a detail view of a portion of a jaw comprising a sheet covering the protective caps positioned within the jaw of FIG. 202;

FIG. 204 is a cross-sectional view of a protective cap positioned on a tip of a staple leg in accordance with at least one alternative embodiment wherein the protective cap comprises an interior forming surface;

FIG. 205 is another cross-sectional view of the protective cap of FIG. 204 illustrating the staple leg being deformed against the forming surface;

FIG. 206 is a top view of an alternative embodiment of a retention matrix comprising a plurality of connected matrix elements;

FIG. 207 is a top view of an alternative embodiment of a retention matrix comprising a plurality of connected matrix elements;

FIG. 208 is a top view of an alternative embodiment of a retention matrix comprising a plurality of connected matrix elements;

FIG. 209 is a top view of an alternative embodiment of an array of retention matrices comprising a plurality of connected matrix elements;

FIG. 210 is a top view of an alternative embodiment of a retention matrix comprising a plurality of connected matrix elements;

FIG. 211 is a partial exploded view of a jaw comprising a retention matrix including a compressible cover;

FIG. 212 is a detail view of the retention matrix of FIG. 211;

FIG. 213 is a partial cross-sectional view of a fastening system comprising a retention matrix including a compressible layer and a plurality of cells encapsulating one or more medicaments;

FIG. 214 is a diagram illustrating staple legs which have pierced the cells of FIG. 213 as they are being engaged with the retention matrix;

FIG. 215 is a partial cross-sectional view of a fastening system comprising a retention matrix including a compressible layer;

FIG. 216 is an elevational view of a fastener cartridge insertion assembly comprising a holder, a first fastener cartridge, and a second fastener cartridge;

FIG. 217 is an elevational view of an end effector of a surgical stapler comprising a first jaw and a second jaw, the second jaw being illustrated in an open configuration;

FIG. 218 is an elevational view of the end effector of FIG. 217 illustrating the second jaw in a closed configuration and the fastener cartridge insertion assembly of FIG. 216 being used to load the first jaw with the first cartridge and the second jaw with the second cartridge;

FIG. 219 is an elevational view of the loaded end effector of FIG. 218 illustrating the cartridge insertion assembly removed from the end effector, the second jaw in an open configuration once again, and tissue positioned intermediate the first jaw and the second jaw;

FIG. 220 is an elevational view of the loaded end effector of FIG. 219 in a fired configuration;

FIG. 221 is an elevational view of the first cartridge and the second cartridge in an implanted condition;

14

FIG. 222 is an elevational view of the end effector of FIG. 217 illustrating a portion of the first cartridge still engaged with the first jaw in accordance with at least one embodiment;

FIG. 223 is an elevational view of an alternative embodiment of a fastener cartridge insertion assembly comprising a holder, a first fastener cartridge, and a second fastener cartridge;

FIG. 224 is an elevational view of the fastener cartridge insertion assembly of FIG. 223 being used to load a first jaw of an end effector with the first cartridge and a second jaw with the second cartridge;

FIG. 225 is a cross-sectional view of the loaded end effector of FIG. 224;

FIG. 226 is a perspective view of a surgical stapler comprising a bottom jaw and a top jaw in accordance with at least one embodiment illustrated with portions of the surgical stapler removed;

FIG. 227 is a perspective view of the surgical stapler of FIG. 226 with the top jaw removed;

FIG. 228 is a perspective view of a slidable anvil system of the top jaw of the surgical stapler of FIG. 226 comprising a first slidable anvil and a second slidable anvil;

FIG. 229 is an end view of the slidable anvil system of FIG. 228;

FIG. 230 is a top view of the slidable anvil system of FIG. 228;

FIG. 231 is a diagram illustrating the slidable anvil system of FIG. 228 in an unfired condition;

FIG. 232 is a diagram illustrating the first slidable anvil of the slidable anvil system of FIG. 228 in an unfired position and staples positioned within the bottom jaw in an undeployed position;

FIG. 233 is a diagram illustrating the staples in the bottom jaw in a deployed configuration and the first slidable anvil of FIG. 232 being pulled proximally to deform a first group of staple legs of the staples;

FIG. 234 is a diagram illustrating the first group of staples of FIG. 233 deformed to a fully deformed state;

FIG. 235 is a diagram illustrating the second slidable anvil of the slidable anvil system of FIG. 228 being pushed distally to deform a second group of staple legs;

FIG. 236 is a partial perspective view of an anvil comprising a plurality of forming pockets in at least one embodiment;

FIG. 237 is a cross-sectional end view of the anvil of FIG. 236;

FIG. 238 is a diagram illustrating a first step in manufacturing the forming pockets of FIG. 236;

FIG. 239 is a diagram illustrating a second step in manufacturing the forming pockets of FIG. 236;

FIG. 240 is a top view of the forming pocket arrangement of the anvil of FIG. 236;

FIG. 241 is a diagram illustrating a first step of a manufacturing process for producing an anvil;

FIG. 242 is a diagram illustrating a second step in the manufacturing process of FIG. 241; and

FIG. 243 is a diagram illustrating a third step in the manufacturing process of FIG. 241.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate preferred embodiments of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION

The Applicant of the present application also owns the U.S. Patent Applications identified below which were filed on even

date herewith and which are each herein incorporated by reference in their respective entirety:

U.S. patent application Ser. No. 12/894,360, now U.S. Patent Application Publication No. 2012/0080484, entitled “Surgical Stapling Instrument With a Variable Staple Forming System”;

U.S. patent application Ser. No. 12/894,322, now U.S. Patent Application Publication No. 2012/0080501, entitled “Surgical Stapling Instrument With Interchangeable Staple Cartridge Arrangements”;

U.S. patent application Ser. No. 12/894,351, now U.S. Patent Application Publication No. 2012/0080502, entitled “Surgical Cutting and Fastening Instruments With Separate and Distinct Fastener Deployment and Tissue Cutting Systems”;

U.S. patent application Ser. No. 12/894,339, now U.S. Patent Application Publication No. 2012/0080500, entitled “Surgical Stapling Instrument With Compact Articulation Control Arrangement”;

U.S. patent application Ser. No. 12/894,327, now U.S. Patent Application Publication No. 2012/0080499, entitled “Jaw Closure Arrangements For Surgical Instruments”;

U.S. patent application Ser. No. 12/894,340, now U.S. Patent Application Publication No. 2012/0080482, entitled “Surgical Staple Cartridges Supporting Non-Linearly Arranged Staples and Surgical Stapling Instruments With Common Staple-Forming Pockets”;

U.S. patent application Ser. No. 12/894,350, now U.S. Patent Application Publication No. 2012/0080478, entitled “Surgical Staple Cartridges With Detachable Support Structures and Surgical Stapling Instruments With Systems For Preventing Actuation Motions When a Cartridge is Not Present”;

U.S. patent application Ser. No. 12/894,338, now U.S. Patent Application Publication No. 2012/0080481, entitled “Implantable Fastener Cartridge Having a Non-Uniform Arrangement”;

U.S. patent application Ser. No. 12/894,369, now U.S. Patent Application Publication No. 2012/0080344, entitled “Implantable Fastener Cartridge Comprising a Support Retainer”;

U.S. patent application Ser. No. 12/894,312, now U.S. Patent Application Publication No. 2012/0080479, entitled “Implantable Fastener Cartridge Comprising Multiple Layers”;

U.S. patent application Ser. No. 12/894,377, now U.S. Pat. No. 8,393,514, entitled “Selectively Orientable Implantable Fastener Cartridge”;

U.S. patent application Ser. No. 12/894,383, now U.S. Patent Application Publication No. 2012/0080345, entitled “Implantable Fastener Cartridge Comprising Bioabsorbable Layers”;

U.S. patent application Ser. No. 12/894,389, now U.S. Patent Application Publication No. 2012/0080335, entitled “Compressible Fastener Cartridge”;

U.S. patent application Ser. No. 12/894,345, now U.S. Patent Application Publication No. 2012/0080483, entitled “Fasteners Supported By a Fastener Cartridge Support”;

U.S. patent application Ser. No. 12/894,306, now U.S. Patent Application Publication No. 2012/0080332, entitled “Collapsible Fastener Cartridge”;

U.S. patent application Ser. No. 12/894,318, now U.S. Patent Application Publication No. 2012/0080480, entitled “Fastener System Comprising a Plurality of Connected Retention Matrix Elements”;

U.S. patent application Ser. No. 12/894,330, now U.S. Patent Application Publication No. 2012/0080503, entitled “Fastener System Comprising a Retention Matrix and an Alignment Matrix”;

U.S. patent application Ser. No. 12/894,361, now U.S. Pat. No. 8,529,600, entitled “Fastener System Comprising a Retention Matrix”;

U.S. patent application Ser. No. 12/894,367, now U.S. Patent Application Publication No. 2012/0080485, entitled “Fastening Instrument For Deploying a Fastener System Comprising a Retention Matrix”;

U.S. patent application Ser. No. 12/894,388, now U.S. Pat. No. 8,474,677, entitled “Fastener System Comprising a Retention Matrix and a Cover”; and

U.S. patent application Ser. No. 12/894,376, now U.S. Patent Application Publication No. 2012/0080486, entitled “Fastener System Comprising a Plurality of Fastener Cartridges”.

Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the various embodiments of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

Reference throughout the specification to “various embodiments,” “some embodiments,” “one embodiment,” or “an embodiment”, or the like, means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases “in various embodiments,” “in some embodiments,” “in one embodiment”, or “in an embodiment”, or the like, in places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Thus, the particular features, structures, or characteristics illustrated or described in connection with one embodiment may be combined, in whole or in part, with the features structures, or characteristics of one or more other embodiments without limitation. Such modifications and variations are intended to be included within the scope of the present invention.

The terms “proximal” and “distal” are used herein with reference to a clinician manipulating the handle portion of the surgical instrument. The term “proximal” referring to the portion closest to the clinician and the term “distal” referring to the portion located away from the clinician. It will be further appreciated that, for convenience and clarity, spatial terms such as “vertical”, “horizontal”, “up”, and “down” may be used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and/or absolute.

Various exemplary devices and methods are provided for performing laparoscopic and minimally invasive surgical procedures. However, the person of ordinary skill in the art will readily appreciate that the various methods and devices disclosed herein can be used in numerous surgical procedures

17

and applications including, for example, in connection with open surgical procedures. As the present Detailed Description proceeds, those of ordinary skill in the art will further appreciate that the various instruments disclosed herein can be inserted into a body in any way, such as through a natural orifice, through an incision or puncture hole formed in tissue, etc. The working portions or end effector portions of the instruments can be inserted directly into a patient's body or can be inserted through an access device that has a working channel through which the end effector and elongated shaft of a surgical instrument can be advanced.

Turning to the Drawings wherein like numerals denote like components throughout the several views, FIG. 1 depicts a surgical instrument 10 that is capable of practicing several unique benefits of the present invention. The surgical stapling instrument 10 is designed to manipulate and/or actuate various forms and sizes of end effectors 12 that are operably attached thereto. In the embodiment depicted in FIGS. 1 and 2, for example, the end effector 12 includes an elongated channel 14 that forms a lower jaw 13 of the end effector 12. The elongated channel 14 is configured to support an "implantable" staple cartridge 30 and also movably support an anvil 20 that functions as an upper jaw 15 of the end effector 12.

In various embodiments, the elongated channel 14 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and be formed with spaced side walls 16. The anvil 20 may be fabricated from, for example, 300 & 400 Series, 17-4 & 17-7 stainless steel, titanium, etc. and have a staple forming undersurface, generally labeled as 22 that has a plurality of staple forming pockets 23 formed therein. See FIGS. 1B-1E. In addition, the anvil 20 has a bifurcated ramp assembly 24 that protrudes proximally therefrom. An anvil pin 26 protrudes from each lateral side of the ramp assembly 24 to be received within a corresponding slot or opening 18 in the side walls 16 of the elongated channel 14 to facilitate its movable or pivotable attachment thereto.

Various forms of implantable staple cartridges may be employed with the various embodiments of the surgical instruments disclosed herein. Specific staple cartridge configurations and constructions will be discussed in further detail below. However, in the embodiment depicted in FIGS. 1A and 9-14, an implantable staple cartridge 30 is shown. In at least one embodiment, the staple cartridge 30 has a body portion 31 that consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose ("ORC") or a bio-absorbable foam in which lines of unformed metal staples 32 are supported. In at least some embodiments, in order to prevent the staple from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge may be coated or wrapped in a biodegradable film 38 such as a polydioxanone film sold under the trademark PDS® or with a Polyglycerol sebacate (PGS) film or other biodegradable films formed from PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglicaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured. The body 31 of staple cartridge 30 is sized to be removably supported within the elongated channel 14 as shown such that each staple 32 therein is aligned with corresponding staple forming pockets 23 in the anvil when the anvil 20 is driven into forming contact with the staple cartridge 30.

In use, once the end effector 12 has been positioned adjacent the target tissue, the end effector 12 is manipulated to

18

capture or clamp the target tissue between an upper face 36 of the staple cartridge 30 and the staple forming surface 22 of the anvil 20. The staples 32 are formed by moving the anvil 20 in a path that is substantially parallel to the elongated channel 14 to bring the staple forming surface 22 and, more particularly, the staple forming pockets 23 therein into substantially simultaneous contact with the upper face 36 of the staple cartridge 30. As the anvil 20 continues to move into the staple cartridge 30, the legs 34 of the staples 32 contact a corresponding staple forming pocket 23 in anvil 20 which serves to bend the staple legs 34 over to form the staples 32 into a "B shape". Further movement of the anvil 20 toward the elongated channel 14 will further compress and form the staples 32 to a desired final formed height "FH".

The above-described staple forming process is generally depicted in FIGS. 1B-1E. For example, FIG. 1B illustrates the end effector 12 with target tissue "T" between the anvil 20 and the upper face 36 of the implantable staple cartridge 30. FIG. 1C illustrates the initial clamping position of the anvil 20 wherein the anvil 20 has been closed onto the target tissue "T" to clamp the target tissue "T" between the anvil 20 and the upper face 36 of the staple cartridge 30. FIG. 1D illustrates the initial staple formation wherein the anvil 20 has started to compress the staple cartridge 30 such that the legs 34 of the staples 32 are starting to be formed by the staple forming pockets 23 in the anvil 20. FIG. 1E illustrates the staple 32 in its final formed condition through the target tissue "T" with the anvil 20 removed for clarity purposes. Once the staples 32 have been formed and fastened to the target tissue "T", the surgeon will move the anvil 20 to the open position to enable the cartridge body 31 and the staples 32 to remain affixed to the target tissue while the end effector 12 is being withdrawn from the patient. The end effector 12 forms all of the staples simultaneously as the two jaws 13, 15 are clamped together. The remaining "crushed" body materials 31 act as both a hemostat (the ORC) and a staple line reinforcement (PGA, PDS or any of the other film compositions mentioned above 38). Also, since the staples 32 never have to leave the cartridge body 31 during forming, the likelihood of the staples 32 being malformed during forming is minimized. As used herein the term "implantable" means that, in addition to the staples, the cartridge body materials that support the staples will also remain in the patient and eventually be absorbed by the patient's body. Such implantable staple cartridges are distinguishable from prior cartridge arrangements that remain with the end effector and are removed therewith. Those "removable" staple cartridges typically include staple driver components and therefore may be much larger than the end effectors of the present invention that are designed to be employed in connection with certain unique and novel implantable staple cartridge embodiments of the present invention.

In various implementations, the end effector 12 is configured to be coupled to an elongated shaft assembly 40 that protrudes from a handle assembly 100. The end effector 12 (when closed) and the elongated shaft assembly 40 may have similar cross-sectional shapes and be sized to operably pass through a trocar tube or working channel in another form of access instrument. As used herein, the term "operably pass" means that the end effector and at least a portion of the elongated shaft assembly may be inserted through or passed through the channel or tube opening and can be manipulated therein as needed to complete the surgical stapling procedure. In some embodiments, when in a closed position, the jaws 13 and 15 of the end effector 12 may provide the end effector with a roughly circular cross-sectional shape that facilitates its passage through a circular passage/opening. However, the end effectors of various embodiments of the present inven-

19

tion, as well as the elongated shaft assembly embodiments, could conceivably be provided with other cross-sectional shapes that could otherwise pass through access passages and openings that have non-circular cross-sectional shapes. Thus, an overall size of a cross-section of a closed end effector will be related to the size of the passage or opening through which it is intended to pass. Thus, one end effector for example, may be referred to as a "5 mm" end effector which means it can operably pass through an opening that is at least approximately 5 mm in diameter.

In various embodiments of the present invention, the elongated shaft assembly 40 may have an outer diameter that is substantially the same as the outer diameter of the end effector 12 when in a closed position. For example, a 5 mm end effector may be coupled to an elongated shaft assembly 40 that has 5 mm cross-sectional diameter. However, as the present Detailed Description proceeds, it will become apparent that various embodiments of the present may be effectively used in connection with different sizes of end effectors. For example, a 10 mm end effector may be attached to an elongated shaft that has a 5 mm cross-sectional diameter. Conversely, for those applications wherein a 10 mm or larger access opening or passage is provided, the elongated shaft assembly 40 may have a 10 mm (or larger) cross-sectional diameter, but may also be able to actuate a 5 mm or 10 mm end effector. Accordingly, the outer shaft 40 may have an outer diameter that is the same as or is different from the outer diameter of a closed end effector 12 attached thereto.

As depicted, the elongated shaft assembly 40 extends distally from the handle assembly 100 in a generally straight line to define a longitudinal axis A-A. In various embodiments, for example, the elongated shaft assembly 40 may be approximately 9-16 inches (229-406 mm) long. However, the elongated shaft assembly 40 may be provided in other lengths and, in other embodiments, may have joints therein or be otherwise configured to facilitate articulation of the end effector 12 relative to other portions of the shaft or handle assembly as will be discussed in further detail below. In various embodiments, the elongated shaft assembly 40 includes a spine member 50 that extends from the handle assembly 100 to the end effector 12. The proximal end of the elongated channel 14 of the end effector 12 has a pair of retention trunions 17 protruding therefrom that are sized to be received within corresponding trunion openings or cradles 52 that are provided in a distal end of the spine member 50 to enable the end effector 12 to be removably coupled the elongated shaft assembly 40. The spine member 50 may be fabricated from, for example, 6061 or 7075 aluminum, stainless steel, titanium, etc.

In various embodiments, the handle assembly 100 comprises a pistol grip-type housing that may be fabricated in two or more pieces for assembly purposes. For example, the handle assembly 100 as shown comprises a right hand case member 102 and a left hand case member 104 (FIGS. 5, 7, and 8) that are molded or otherwise fabricated from a polymer or plastic material and are designed to mate together. Such case members 102 and 104 may be attached together by snap features, pegs and sockets molded or otherwise formed therein and/or by adhesive, screws, etc. The spine member 50 has a proximal end 54 that has a flange 56 formed thereon. The flange 56 is configured to be rotatably supported within a groove 106 formed by mating ribs 108 that protrude inwardly from each of the case members 102, 104. Such arrangement facilitates the attachment of the spine member 50 to the handle assembly 100 while enabling the spine member 50 to be rotated relative to the handle assembly 100 about the longitudinal axis A-A in a 360° path.

20

As can be further seen in FIGS. 1 and 4, the spine member 50 passes through and is supported by a mounting bushing 60 that is rotatably affixed to the handle assembly 100. The mounting bushing 60 has a proximal flange 62 and a distal flange 64 that define a rotational groove 65 that is configured to rotatably receive a nose portion 101 of the handle assembly 100 therebetween. Such arrangement enables the mounting bushing 60 to rotate about longitudinal axis A-A relative to the handle assembly 100. The spine member 50 is non-rotatably pinned to the mounting bushing 60 by a spine pin 66. In addition, a rotation knob 70 is attached to the mounting bushing 60. In one embodiment, for example, the rotation knob 70 has a hollow mounting flange portion 72 that is sized to receive a portion of the mounting bushing 60 therein. In various embodiments, the rotation knob 70 may be fabricated from, for example, glass or carbon filled Nylon, polycarbonate, Ultem®, etc. and is affixed to the mounting bushing 60 by the spine pin 66 as well. In addition, an inwardly protruding retention flange 74 is formed on the mounting flange portion 72 and is configured to extend into a radial groove 68 formed in the mounting bushing 60. Thus, the surgeon may rotate the spine member 50 (and the end effector 12 attached thereto) about longitudinal axis A-A in a 360° path by grasping the rotation knob 70 and rotating it relative to the handle assembly 100.

In various embodiments, the anvil 20 is retained in an open position by an anvil spring 21 or other biasing arrangement as depicted in FIGS. 1, 9A, 10A, and 11A. The anvil 20 is selectively movable from the open position to various closed or clamping and firing positions by a firing system, generally designated as 109. The firing system 109 includes a "firing member" 110 which, in various embodiments, comprises a hollow firing tube 110. The hollow firing tube 110 is axially movable on the spine member 50 and thus forms the outer portion of the elongated shaft assembly 40. The firing tube 110 may be fabricated from a polymer or other suitable material and have a proximal end 112 that is attached to a firing yoke 114 of the firing system 109. See FIG. 4. In various embodiments for example, the firing yoke 114 may be overmolded to the proximal end 112 of the firing tube 110. However, other fastener arrangements may be employed.

As can be seen in FIGS. 1 and 4, the firing yoke 114 may be rotatably supported within a support collar 120 that is configured to move axially within the handle assembly 100. In various embodiments, the support collar 120 has a pair of laterally extending fins 122 that are sized to be slidably received within fin slots 103 and 105 formed in the right and left hand case members 102, 104, respectively. See FIG. 7. Thus, the support collar 120 may slide axially within the handle housing 100 while enabling the firing yoke 114 and firing tube 110 to rotate relative thereto about the longitudinal axis A-A. As can be seen in FIG. 4, a longitudinal slot 111 is provided through the firing tube 110 to enable the spine pin 66 to extend therethrough into the spine member 50 while facilitating the axial travel of the firing tube 110 on the spine member 50.

The firing system 109 further comprises a firing trigger 130 which serves to control the axial travel of the firing tube 110 on the spine member 50. See FIG. 1. Such axial movement in the distal direction of the firing tube 110 into firing interaction with the anvil 20 is referred to herein as "firing motion". As can be seen in FIG. 1, the firing trigger 130 is movably or pivotally coupled to the handle assembly 100 by a pivot pin 132. A torsion spring 135 is employed to bias the firing trigger 130 away from the pistol grip portion 107 of the handle assembly 100 to an un-actuated "open" or starting position. As can be seen in FIGS. 1 and 4, the firing trigger 130 has an

21

upper portion **134** that is movably attached to (pinned) firing links **136** that are movably attached to (pinned) the support collar **120**. Thus, movement of the firing trigger **130** from the starting position (FIGS. **1** and **9**) toward an ending position adjacent the pistol grip portion **107** of the handle assembly **100** (FIG. **14**) will cause the firing yoke **114** and the firing tube **110** to move in the distal direction "DD". Movement of the firing trigger **130** away from the pistol grip portion **107** of the handle assembly **100** (under the bias of the torsion spring **135**) will cause the firing yoke **114** and firing tube **110** to move in the proximal direction "PD" on the spine member **50**.

Various embodiments of the present invention may be employed with different sizes and configurations of implantable staple cartridges. For example, the surgical instrument **10**, when used in connection with a first firing adapter **140**, may be used with a 5 mm end effector **12** that is approximately 20 mm long (or in other lengths) which supports an implantable staple cartridge **30**. Such end effector size may be particularly well-suited, for example, to complete relatively fine dissection and vascular transactions. However, as will be discussed in further detail below, the surgical instrument **10** may also be employed, for example, in connection with other sizes of end effectors and staple cartridges by replacing the first firing adapter **140** with a second firing adapter **150**. In still other embodiments, the elongated shaft assembly **40** may be configured to be attached to only one form or size of end effector. In such embodiments, for example, the pressure surfaces **146** or **158** (normally provided on the firing adapters **140**, **150**, respectively) would be integrally formed in the distal end of the firing tube **110**—depending upon the particular size of end effector with which it is to be used.

As can be seen in FIG. **2**, the first firing adapter **140** is substantially hollow and has a first spring portion **142** that is configured to extend into an open distal end **116** of the firing tube **110**. A first retainer button **144** is formed on the first spring portion **142** and is sized to be received within a retaining hole **117** provided in the distal end portion of the firing tube **110**. See FIGS. **1** and **2**. Thus, to detach the first firing adapter **140** from the firing tube **110**, the user simply depresses the retainer button **144** out of the retaining hole **117** and withdraws the first firing adapter **140** out of the firing tube **110**. As can also be seen in FIG. **2**, the first firing adapter **140** has an interior pressure surface **146** that is configured to interface with the bifurcated ramp assembly **24** of the anvil **20**.

In various implementations, the bifurcated ramp assembly **24** on the anvil **20** comprises a pair of tines **45** that are separated by a blade-receiving groove (not shown). Each tine **45** has a proximal surface **27** that is substantially parallel to the bottom of the elongated channel **14** when the anvil **20** is in a closed position. The proximal surface **27** then transitions into a clamping ramp **28** that is distal to the proximal surface **27**. See FIG. **3**. The clamping ramp **28** is oriented at a clamping angle "A" with respect to the proximal surface **27**. In various embodiments, for example, clamping angle "A" may be approximately 15 to 30 degrees. As will be discussed in further detail below, when the first pressure surface **146** of the first firing adapter **140** contacts the clamping ramp **28**, the anvil **20** will be moved toward the elongated channel **14** and more specifically toward the staple cartridge **30** therein. As the first firing adapter **140** is further moved distally, the first pressure surface **146** contacts a staple forming ramp **29** on each of the anvil tines **45** to further drive the anvil **20** into the staple cartridge **30** to form the staples **32** therein. As is also shown in FIG. **3**, the staple forming ramp **29** is oriented at a forming angle "B" relative to the clamping ramp **27**. In various embodiments, for example, forming angle "B" may be

22

approximately 5 to 20 degrees. The ramp assembly **24** of the anvil **20** may further have a sloped under surface **25** thereon (e.g., angle "C" is approximately 5 to 40 degrees) such that when the anvil **20** is in an open position, the sloped undersurface **25** surface enables the anvil **20** to pivot to a 15° open limit (angle "β" in FIG. **11A**).

One method of removably coupling the end effector **12** to the spine member **50** will now be explained. The coupling process is commenced by inserting the retention trunions **17** on the elongated channel **14** into the trunion cradles **52** in the spine member **50**. Thereafter, the surgeon advances the firing trigger **130** toward the pistol grip **107** of the housing assembly **100** to distally advance the firing tube **110** and the first firing adapter **140** over a proximal end portion **47** of the elongated channel **14** to thereby retain the trunions **17** in their respective cradles **52**. See FIGS. **10** and **10A**. Such position of the first firing adapter **140** over the trunions **17** is referred to herein as the "coupled position". Various embodiments of the present invention may also have an end effector locking assembly **160** for locking the firing trigger **130** in position after an end effector **12** has been attached to the spine member **50**.

More specifically and with reference to FIGS. **5**, **7**, and **8**, one embodiment of the end effector locking assembly **160** includes a retention pin **162** that is movably supported in the upper portion **134** of the firing trigger **130**. The retention pin **162** is spring-biased toward the left hand case member **104** by a retention spring **166**. When the firing trigger **130** is in an un-actuated (starting) position, the retention pin **162** is biased into abutting contact with a start detent **163** that protrudes inwardly from the left hand case member **104**. See FIGS. **7** and **8**. As discussed above, the firing tube **110** must initially be advanced distally to the coupled position wherein the first firing adapter **140** retains the retention trunions **17** of the end effector **12** in the trunion cradles **52** in the spine member **50**. The surgeon advances the firing adapter **140** distally to the coupled position by pulling the firing trigger **130** from the starting position toward the pistol grip **107**. As the firing trigger **130** is initially actuated, the retention pin **162** slides in abutting contact with the start detent **163** until the firing tube **110** has advanced the first firing adapter **140** to the coupled position at which point the retention pin **162** is biased into a locking cavity **164** formed in the left hand case member **104**. See FIG. **8**. In various embodiments, when the retention pin **162** enters into the locking cavity **164**, the pin **162** may make an audible "click" or other sound, as well as provide a tactile indication to the surgeon that the end effector **12** has been "locked" onto the spine member **50**. In addition, the surgeon cannot inadvertently continue to actuate the firing trigger **130** to start to form staples **32** in the end effector **12** without intentionally biasing the retention pin **162** out of the locking cavity **164**. Similarly, if the surgeon releases the firing trigger **130** when in the coupled position, it is retained in that position by the retention pin **162** to prevent the firing trigger **130** from returning to the starting position and thereby releasing the end effector **12** from the spine member **50**.

In various implementations, a firing trigger release button **167** is mounted within the left hand case member **104** of the handle assembly **100** to enable the surgeon to intentionally release the retention pin **162** to enable the firing trigger **130** to be further actuated or returned to the starting position. See FIGS. **5**, **7**, and **8**. The firing trigger release button **167** is movably mounted within the locking cavity **164** and is spring-biased to an un-activated position (FIG. **8**). When the firing trigger release button **167** is pressed inwardly, it contacts the retention pin **162** and moves it out of the locking cavity **163** to enable the firing trigger **130** to be further activated.

23

As thus far described, the surgical instrument **10** may be used as a grasping device to manipulate/position tissue. Further movement of the firing trigger **130** toward the pistol grip portion **107** after the trigger **130** has been unlocked (by depressing the retention release button **167**) will cause the firing adapter **140** to contact the clamping ramp **28** on the anvil **20**. As the pressure surface portion **146** of the first firing adapter rides up the clamping ramp **28**, the anvil will move towards the staple cartridge **30** in the elongated channel **14**. Thus, the surgeon may manipulate the anvil **20** toward and away from the staple cartridge **30** to grasp and release tissue therebetween without forming the staples.

Various embodiments of the present invention may further include a firing system lock button **137** that is pivotally attached to the handle assembly **100**. See FIGS. **1** and **4**. In one form, the firing system lock button **137** has a latch **138** formed on a distal end thereof that is oriented to engage the firing yoke **114** when the firing release button is in a first latching position. As can be seen in FIGS. **1** and **4**, a latch spring **139** serves to bias the firing system lock button **137** to the first latching position (FIGS. **11** and **12**). As will be explained in further detail below, the latch **138** serves to engage the firing yoke **114** at a point where the position of the firing yoke **114** on the spine member **50** corresponds to a point wherein the pressure surface **146** of the first firing adapter **140** is about to distally advance up the clamping ramp **28** on the anvil **20**. It will be understood that, as the first firing adapter **140** advances axially up the clamping ramp **28**, the anvil **20** will move in a path such that its staple forming surface portion **22** is substantially parallel to the upper face **36** of the staple cartridge **30**.

After the end effector **12** has been coupled to the spine member **50**, the staple forming process is commenced by first depressing the firing system lock button **137** to enable the firing yoke **114** to be further moved distally on the spine member **50** and ultimately compress the anvil **20** into the staple cartridge **30**. See FIG. **13**. After depressing the firing system lock button **137**, the surgeon continues to actuate the firing trigger **130** towards the pistol grip **107** thereby driving the pressure surface **146** of the first staple collar **140** up the corresponding staple forming ramp **29** to force the anvil **20** into forming contact with the staples **32** in the staple cartridge **30**. The firing system lock button **137** prevents the inadvertent forming of the staples **32** until the surgeon is ready to start that process. In this embodiment, the surgeon must depress the firing system lock button **137** before the firing trigger **130** may be further actuated to begin the staple forming process.

The surgical instrument **10** may be solely used as a tissue stapling device if so desired. However, various embodiments of the present invention may also include a tissue cutting system, generally designated as **170**. In at least one form, the tissue cutting system **170** comprises a knife member **172** that may be selectively advanced from an un-actuated position adjacent the proximal end of the end effector **12** (FIGS. **1** and **9-13**) to an actuated position (FIG. **14**) by actuating a knife advancement trigger **200**. The knife member **172** is movably supported within the spine member **50** and is attached or otherwise protrudes from a knife rod **180**. The knife member **172** may be fabricated from, for example, 420 or 440 stainless steel with a hardness of greater than 38HRC (Rockwell Hardness C-scale) and have a tissue cutting edge **176** formed on the distal end **174** thereof and be configured to slidably extend through a slot **31** in the anvil **20** and a centrally disposed slot **33** in the staple cartridge **30** to cut through tissue that is clamped in the end effector **12**. See FIG. **14A**. As can be seen in FIG. **4**, the knife rod **180** extends through the spine member **50** and has a proximal end portion **182**. The proximal end

24

portion **182** drivingly interfaces with a knife transmission **190** that is operably attached to the knife advance trigger **200**. In various embodiments, the knife advance trigger **200** is attached to pivot pin **132** such that it may be pivoted or otherwise actuated without actuating the firing trigger **130**. In various embodiments, a first knife gear **192** is also attached to the pivot pin **132** such that actuation of the knife advance trigger **200** also pivots the first knife gear **192**. A firing return spring **202** is attached between the first knife gear **192** and the handle housing **100** to bias the knife advancement trigger **200** to a starting or un-actuated position. See FIGS. **1** and **4**.

Turning to FIGS. **5** and **6**, various embodiments of the knife transmission **190** also include a second knife gear **194** that is rotatably supported on a second gear spindle **193** and in meshing engagement with the first knife gear **192**. The second knife gear **194** is in meshing engagement with a third knife gear **196** that is supported on a third gear spindle **195**. Also supported on the third gear spindle **195** is a fourth knife gear **198**. The fourth knife gear **198** is adapted to drivingly engage a series of annular gear teeth or rings **184** on a proximal end of the knife rod **180**. Thus, such arrangement enables the fourth knife gear **198** to axially drive the knife rod **180** in the distal direction "DD" or proximal direction "PD" while enabling the firing rod **180** to rotate about longitudinal axis A-A with respect to the fourth knife gear **198**. Accordingly, the surgeon may axially advance the firing rod **180** and ultimately the knife member **172** distally by pulling the knife advancement trigger **200** towards the pistol grip **107** of the handle assembly **100**.

Various embodiments of the present invention further include a knife lockout system **210** that prevents the advancement of the knife member **72** unless the firing trigger **130** has been pulled to the fully fired position (FIGS. **13** and **14**). Such feature will therefore prevent the activation of the knife advancement system **170** unless the staples have first been fired or formed into the tissue. As can be seen in FIG. **1**, various implementations of the knife lockout system **210** comprise a knife lockout bar **211** that is pivotally supported within the pistol grip portion **107** of the handle assembly **100**. The knife lockout bar **211** has an activation end **212** that is adapted to be engaged by the firing trigger **130** when the firing trigger **130** is in the fully fired position. In addition, the knife lockout bar **211** has a retaining hook **214** on its other end that is adapted to hookingly engage a latch rod **216** on the first cut gear **192**. A knife lock spring **218** is employed to bias the knife lockout bar **211** to a "locked" position wherein the retaining hook **214** is retained in engagement with the latch rod **216** to thereby prevent actuation of the knife advancement trigger **200** unless the firing trigger **130** is in the fully fired position. See FIG. **9**.

Various methods of operating at least one of the surgical instrument embodiments of the present invention will now be explained with reference to FIGS. **9**, **9A**, **10**, **10A**, **11**, **11A**, **12**, **12A**, **13**, **13A**, **14**, and **14A**. As can be appreciated from reference to FIGS. **1**, **9** and **9A**, when the knife bar **172** is in the depicted "starting" or un-actuated position, the tissue cutting edge **176** is proximal to the distal end of the first firing adapter **140** such that the sharp tissue cutting edge **176** is not exposed to the user. In alternative embodiments, wherein the elongated shaft assembly is manufactured for use with a single form or size of end effector (e.g., wherein the firing adapters **140**, **150** are not employed), the cutting edge **176** of the knife bar **172** would be located proximal to the distal end of the firing tube to prevent the tissue cutting edge **176** from being exposed to the user in those embodiments as well.

FIGS. **9** and **9A** illustrate the end effector **12** after it has been attached to the spine member **50** by inserting the reten-

25

tion trunions 17 on the end effector 12 into the trunion cradles 52 in the spine member 50. As illustrated in FIG. 9, the firing trigger 130 is in an un-actuated or starting position and the end effector 12 has not yet been locked to the spine member 50 by the first firing adapter 140. “P₀” represents the distance that the firing trigger 130 can travel before the first firing adapter 140 starts to travel up the clamping ramp portion 28 of the anvil 20. The knife advancement trigger 200 is also in a locked un-actuated position.

FIGS. 10 and 10A illustrate the position of the firing trigger 130 after it has been advanced to a position wherein the end effector 12 is been locked to the spine member 50 by the first firing adapter 40. This position is referred to herein as the “coupled” position. When in the coupled position, the retention pin 162 has snapped into the locking cavity 164 (FIG. 8) to thereby provide the surgeon with an audible and tactile indication that the end effector 12 is now locked to the spine member 50. The firing trigger 130 cannot be actuated further until the surgeon intentionally depresses the firing trigger release button 167 (FIGS. 5, 7, and 8) to bias the retention pin 62 out of the locking cavity 164. The distance that the distal end 141 of the first firing adapter 140 has traveled is represented as distance “I” (FIG. 10A) and the corresponding distance that the firing yoke 114 has traveled on the spine member 50 is represented as distance “I”. FIGS. 11 and 11A illustrate a position of the firing trigger 130 after the release button (not shown) has been depressed and the surgeon has activated the firing trigger 130 to move the first firing adapter 140 to the beginning of the clamping ramps 28 on the anvil 20. As can be seen in those Figures, the anvil spring 21 has biased the anvil 20 to an open position. The travel of the distal end of the first firing adapter 140 is represented as distance “I₁” and the corresponding distance that the firing yoke 114 has traveled on the spine member 50 is represented as distance “I₁”. FIGS. 12 and 12A illustrate the position of the first firing adapter 140 after it has been advanced to the start of the staple forming ramp 29 of the anvil 20. This position represents the maximum amount of clamping that can be attained before staple formation begins. This position is referred to herein as a “maximum clamped position”. As can be seen in FIG. 12, the firing yoke 114 has contacted the latch 138 on the firing trigger release button 137 and therefore cannot be further advanced distally until the firing trigger release button 137 has been depressed. As can be seen in FIG. 12A, the staple forming surface 22 of the anvil 20 is substantially parallel to the upper face 31 of the staple cartridge 30. The distance between the staple forming portion 22 of the anvil 20 and the top retaining surface of the elongated channel 14 has been represented as “C_{max}”. In various embodiments, C_{max} may be, for example, 0.085 to 0.144 inches (approximately 2.15 to 3.65 mm) for staple cartridges 30 with body portions 31 that have a substantially equivalent thickness. In at least one embodiment, for example, the cartridge thickness may be as much as approximately 0.01 to 0.03 inches (approximately 0.25 mm to 0.76 mm) larger than the staple size. The total distance that the first firing adapter 140 has traveled from the starting position to this maximum clamped position is represented as “I₂” and the corresponding distance that the firing yoke 114 has traveled on the spine member 50 is represented as “I₂”. FIGS. 13 and 13A illustrate the position of the firing yoke 114 in a fully fired position wherein the staples 32 in the staple cartridge 30 have been fully formed. When in that position, the distance between the staple forming portion 22 of the anvil 20 and the top retaining surface of the elongated channel 14 is represented as “C_{min}”. In various embodiments, “C_{min}” may be, for example, approximately 0.015 to 0.030 inches (approximately 0.38 mm to 0.76 mm) for staple car-

26

tridges that support staples that, when unformed, have legs that are approximately 0.075 to 0.134 inches (approximately 1.90 mm to 3.40 mm) long (distance “UF” in FIG. 1A) and when fully formed have a fully formed height of, for example, approximately 0.025 inches to 0.04 inches (approximately 0.63 mm to 1.01 mm) which comprises distance “FF” in FIG. 1D. The total distance that the first firing adapter 140 has traveled from the starting position to this fully fired position is represented as “I₃” and the corresponding distance that the firing yoke 114 has traveled on the spine member 50 is represented as “I₃”. As can also be seen in FIG. 13, the firing trigger 130 is in the fully fired position and has contacted the activation end 212 of the knife lockout bar 211 to bias the retaining hook 214 out of engagement with the latch rod 216 on the first cut gear 192.

Transection, especially of vessels may be one of the highest stress steps of any surgical procedure. In the laparoscopic environment, it is even more stressful because if something fails, the entire procedure may need to be converted to an open procedure almost immediately in order to prevent catastrophic events from occurring. Thus, it may be desirable to employ a surgical stapling instrument that has the ability to optionally cut tissue after the staples have been deployed. Various embodiments of the present invention meet such needs.

After the staples have been “fired” (formed) into the target tissue, the surgeon may depress the firing trigger release button 167 to enable the firing trigger 130 to return to the starting position under the bias of the torsion spring 135 which enables the anvil 20 to be biased to an open position under the bias of spring 21. When in the open position, the surgeon may withdraw the end effector 12 leaving the implantable staple cartridge 30 and staples 32 behind. In applications wherein the end effector was inserted through a passage, working channel, etc. the surgeon will return the anvil 20 to the closed position by activating the firing trigger 130 to enable the end effector 12 to be withdrawn out through the passage or working channel. If, however, the surgeon desires to cut the target tissue after firing the staples, the surgeon activates the knife advancement trigger 200 in the above-described manner to drive the knife bar 72 through the target tissue to the end of the end effector as shown in FIGS. 14, 14A. FIG. 14 illustrates the amount of travel of the knife advancement trigger 200 in various embodiments for different lengths of end effectors/staple cartridges wherein the knife bar 72 has been advanced to the fully fired position within the end effector 12. Thereafter, the surgeon may release the knife advancement trigger 200 to enable the firing return spring 202 to cause the firing transmission to return the knife bar 72 to the starting (un-actuated) position (FIGS. 13, 13A). Once the knife bar 72 has been returned to the starting position, the surgeon may open the end effector jaws 13, 15 to release the implantable cartridge 30 within the patient and then withdraw the end effector 12 from the patient. Thus, such surgical instruments of the present invention facilitate the use of small implantable staple cartridges that may be inserted through relatively smaller working channels and passages, while providing the surgeon with the option to fire the staples without cutting tissue or if desired to also cut tissue after the staples have been fired.

As indicated above, the surgical instrument 10 can be employed in connection with other end effectors that support other sizes of staple cartridges that contain other sizes and numbers of staples. FIGS. 15-19 illustrate use of an end effector 12' which operably supports a staple cartridge 30' that has staples 32' that are larger than the staples 32 in the staple cartridge 30. For example, the staples 32 in a staple cartridge

27

30 may be approximately 0.080-0.085 inches (approximately 2.03 to 2.15 mm staples, whereas the staples **32'** in the staple cartridge **30'** may be approximately 0.075 inches (approximately 1.90 mm). In various embodiments, the staple cartridge **30'** is longer than the staple cartridge **30**. For example, the staple cartridge **30** may be approximately 0.78 inches (approximately 20 mm) long; whereas the staple cartridge **30'** may be approximately 1.57 inches (approximately 40 mm) long. FIG. 15 is an exploded view of an end effector **12'**, a second firing adapter **150** and the distal end **55** of the spine member **50**. As can be seen in FIG. 15, the elongated channel **14'** has a pair of spaced side walls **16'** that each has a slot or opening **18'** therein that is sized to receive a corresponding anvil pin **26'**. The anvil **20'** and the elongated channel **14'** may together form an end effector **12'** that has an overall diameter that would permit the end effector **12'** to pass through an opening that has a diameter of at least approximately 0.20 inches (approximately 5.0 mm). The anvil **20'** also has a staple forming portion **22'** that has a plurality of staple forming pockets formed therein and a bifurcated ramp assembly **24'** that protrudes proximally therefrom. The proximal end **15'** of the elongated channel **14'** has a pair of retention trunions **17'** protruding therefrom that are sized to be received within corresponding trunion cradles **52** that are provided in the spine member **50**.

As can be seen in FIG. 15, the second firing adapter **150** has a substantially hollow body portion **151** and a proximal collar portion **152** that has an inwardly extending retaining protrusion **154** therein. A slot **156** is provided between the body portion **151** and the proximal collar portion **152** to enable the collar portion **152** to be biased relative to the body portion **151** to facilitate the insertion of the retaining protrusion **154** into the retaining hole **117** in the firing tube **110**. To detach the second firing adapter **150** from the firing tube **110**, the surgeon depresses the proximal collar portion **152** to move the retaining protrusion **154** out of the retaining hole **117** to thereby enable the second firing adapter **150** to be pulled distally off of the firing tube **110**.

In various embodiments, the anvil **20'** has a bifurcated ramp assembly **24'** that comprises a pair of tines **45'** that each has a proximal surface **27'** that transitions into a clamping ramp **28'** that is distal to the proximal surface **27'**. See FIG. 15. The clamping ramp **28'** is oriented at an angle "A" with respect to the proximal surface **27'**. In various embodiments, for example, angle "A" may be approximately 50 to 30 degrees. As will be discussed in further detail below, when a second pressure surface **158** of the second firing adapter **150** contacts the clamping ramps **28'**, the anvil **20'** will be moved toward the elongated channel **14'** and more specifically toward the staple cartridge **30'** therein. See FIG. 17. As the second firing adapter **150** is further moved distally, the second pressure surface **158** contacts staple forming ramps **29'** on the anvil tines **45** to further drive the anvil **20'** toward the staple cartridge **30'** to form the staples **32'** therein. See FIG. 18. The staple forming ramp **29'** is oriented at an angle "B" relative to the clamping ramp **27'**. In various embodiments, for example, angle "B" may be approximately 5 to 20 degrees. A spring (not shown) may be provided between the ramp assembly **24'** and the bottom of the elongated channel **14'** to bias the anvil **20'** to that open position.

FIG. 16 shows the position of the second firing adapter **150** after the surgeon has distally advanced the second firing adapter **150** to the start of the clamping ramp portions **28'**. Operation of the second firing adapter **150** is controlled by the firing trigger **130** in the manner described above with respect to the first firing adapter **140**. FIG. 17 illustrates the position of the second firing adapter **150** in a fully clamped position.

28

FIG. 18 illustrates the position of the second firing adapter **150** in the fully fired position wherein the staples **32'** in the staple cartridge **30'** have been formed through the clamped tissue (not shown).

As indicated above, the implantable staple cartridge **30'** is longer than the implantable staple cartridge **30**. Thus, as shown in FIG. 15, the end effector **12'** also includes a distal knife member **124** that is movably supported in the elongated channel **14'**. The distal knife member **124** has a tissue cutting edge **125** and a proximal portion **126** that is configured for engagement by the knife bar **72**. Thus, if the surgeon desires to cut the tissue after the staples have been fired, the surgeon activates the firing trigger **200** as described above to drive the knife bar **172** distally into contact with the distal knife member **124** to drive the distal knife member **124** through the tissue as illustrated in FIG. 19. The distal knife member **124** may have at least one retainer portion thereon that is adapted to slide through a correspondingly shaped slot (not shown) in the elongated channel **14'**. Such arrangement enables the end effector **12'** to be opened after the staples have been formed and the tissue has been cut. The distal knife member **124** remains in the anvil **20'** and is removed with the end effector **12'** when it is withdrawn from the patient.

Thus, various embodiments of the surgical instrument **10** have separate stapling and tissue cutting mechanisms such that the surgeon may staple the tissue without cutting the tissue. The various embodiments of the stapling instrument of the present invention can be successfully employed with different sizes of end effectors that are adapted to fire different sizes and numbers of staples. The surgical instruments may be provided in the form of a kit that includes an instrument **10** and a first firing adapter **140** and a second firing adapter **150** that enables the instrument to be employed to fire different sizes of implantable staple cartridges.

Various unique and novel embodiments of the present invention employ a compressible staple cartridge that supports staples in a substantially stationary position for forming contact by the anvil. Unlike prior surgical stapling arrangements that employ staple driving elements, the staples in the cartridges of various embodiments of the present invention are not driven into the anvil. In the various embodiments of the present invention, the anvil is driven into the unformed staples. The degree of staple formation attained is dependent upon how far the anvil is driven into the staples. Such arrangement provides the surgeon with the ability to adjust the amount of forming or firing pressure applied to the staples and thereby alter the final formed height of the staples.

In various embodiments, the amount of firing motion that is applied to the movable anvil is dependent upon the degree of actuation of the firing trigger. For example, if the surgeon desires to attain only partially formed staples, then the firing trigger is only partially depressed inward towards the pistol grip **107**. To attain more staple formation, the surgeon simply compresses the firing trigger further which results in the anvil being further driven into forming contact with the staples. As used herein, the term "forming contact" means that the staple forming surface or staple forming pockets have contacted the ends of the staple legs and have started to form or bend the legs over into a formed position. The degree of staple formation refers to how far the staple legs have been folded over and ultimately relates to the forming height of the staple as referenced above. Those of ordinary skill in the art will further understand that, because the anvil **20** moves in a substantially parallel relationship with respect to the staple cartridge as the firing motions are applied thereto, the staples are formed substantially simultaneously with substantially the same formed heights.

29

FIGS. 20-23 illustrate an alternative surgical instrument 10 that employs a staple height indicator assembly 220. In various embodiments, the staple height indicator assembly 220 comprises an indicator bar 222 that is attached to the upper portion 134 of the firing trigger 130 for pivotal travel therewith. As the firing trigger 130 is pivoted toward the pistol portion 107 of the handle assembly 100 to compress the anvil 20 into the staple cartridge 30 as described above, the indicator bar 222 is viewable through a window 223 in the left hand case member 104. In this embodiment, the staple height indicator assembly 220 also includes a series of detents 24, 26, 28 that are formed in the left hand case member 104 and which correspond to three stages of staple formation. In particular, once the firing trigger 130 is initially actuated, the retention pin 162 slides in abutting contact with the start detent 163 until the firing tube 110 has advanced the firing adapter 140 or 150 to the above-described locking position at which point the retention pin 162 is biased into a locking cavity 164 formed in the left hand case member 104. When the surgeon desires to start to close the jaws 13, 35 of the end effector 12, the retention release button 167 is depressed to enable the firing trigger 130 to be further actuated. When the firing trigger release button 167 is pressed inwardly, it contacts the retention pin 162 and moves it out of the locking cavity 163 to enable the firing trigger 130 to be activated. As described above, the surgeon may now use the bottom and top jaws 13, 15, respectively of the end effector 12 to grasp and manipulate tissue. When the surgeon desires to commence the staple forming process, the firing trigger release button 167 is depressed which enables the firing yoke 114 to be advanced distally as the surgeon continues to depress the firing trigger 130.

Further advancement of the firing trigger 130 moves the anvil 20 into forming contact with the staples 32 in the staple cartridge 30. As the firing trigger 130 is further depressed, the flat end 165 of the retention pin 162 will slide off of starting detent 163 and contact the first detent 224 that corresponds to a first amount of staple formation that is represented by a first staple height symbol 230 on the left hand case member 104. See FIG. 20. As shown, the first staple height symbol 230 comprises a picture of a staple that has just started to form. Other symbols/indicia could be used to designate this stage of staple formation. As the retention pin 162 engages the first detent 224 and audible click may be heard by the surgeon. The engagement of the retention pin 162 with the first detent 224 may also provide some tactile feedback to the surgeon through the firing trigger 130. In addition, the staple height indicator bar 222 may be viewed through the viewing window 223 adjacent to the first height staple symbol 230. If the surgeon desires to further form the staples 32 in the staple cartridge, the retention pin 162 is pressed out of engagement with the first detent 224 by a release button 240 that is formed into the second hand case member 104. In various embodiments for example, the release button 240 may be integrally formed into the left hand case member 104 with a hinge portion 242 that is part of the left hand case member 104. Such arrangement enables the release button 240 to be pressed into the end 165 of the retention pin 162 to move it out of engagement with any of the first, second and third detents 224, 226, 228. Once the retention pin 162 has been pressed out of the first detent 224, the firing trigger 130 may be further depressed until the retention pin 162 engages the second staple formation detent 226. Such position of the firing trigger 130 has resulted in further movement of the anvil 20 into staple forming contact with the staples 32 in the staple cartridge 30. Again, the retention pin 162 snaps into the second staple formation detent 226 providing the surgeon

30

with audible and tactile feedback that the firing trigger 130 is in the second staple formation position. When in that position, the staple height indicator bar 222 may be viewed through the viewing window 223 and is adjacent to the second staple height symbol 232. If the surgeon desires to further form the staples 32 in the staple cartridge 30, the retention pin 162 is pressed out of engagement with the second detent 226 by depressing the release button 240. Thereafter, the firing trigger 130 may be depressed further until the retention pin 162 engages the third staple formation detent 228 corresponding to the final stage of staple formation. Again, the retention pin 162 snaps into the third staple formation detent 228 providing the surgeon with audible and tactile feedback that the firing trigger 130 is in the third staple formation position. When in that position, the staple height indicator bar 222 may be viewed through the viewing window 223 and is adjacent to the staple height symbol 234. After the staples have been formed a desired amount, the surgeon may bias the retention pin 162 out of the third staple height detent 228 to enable the firing trigger 130 to return to the starting position. Or, if desired, the surgeon may then commence the tissue cutting procedure as described above before returning the firing trigger 130 to the starting position.

FIG. 24 illustrates an alternative embodiment wherein the staple height indicator assembly, generally designated as 220', does not include the series of detents that correspond to the various staple formations. This embodiment, however, does include the staple height indicator bar 222 and viewing window 223. Thus, the surgeon may monitor the amount of staple formation being achieved by monitoring the position of the staple height indicator bar 222 through the viewing window 223. This embodiment does include the staple height indicator symbols 230, 232, 234 as described above. In addition, this embodiment may also include an unformed staple symbol 229 that corresponds to the starting position wherein the staples 32 have not yet started to be formed by the anvil 20. This embodiment would otherwise operate in the same manners described above.

FIGS. 25 and 26 illustrate an alternative end effector 12' that is similar to the end effector 12 described above, except with the following differences that are configured to accommodate a knife bar 172'. The knife bar 172' is coupled to or protrudes from a knife rod 180 and is otherwise operated in the above described manner with respect to the knife bar 172. However, in this embodiment, the knife bar 172' is long enough to traverse the entire length of the end effector 12' and therefore, a separate distal knife member is not employed in the end effector 12'. The knife bar 172' has an upper transverse member 173' and a lower transverse member 175' formed thereon. The upper transverse member 173' is oriented to slidably transverse a corresponding elongated slot 250 in anvil 20" and the lower transverse member 175' is oriented to traverse an elongated slot 252 in the elongated channel 14" of the end effector 12". A disengagement slot (not shown) is also provided in the anvil 20" such that when the knife bar 172' has been driven to an ending position with thin end effector 12", the upper transverse member 173' drops through the corresponding slot to enable the anvil 20" to move to the open position to disengage the stapled and cut tissue. The anvil 20" may be otherwise identical to anvil 20 described above and the elongated channel 14" may be otherwise identical to elongated channel 14 described above.

In these embodiments, the anvil 20" is biased to a fully open position (FIG. 25) by a spring or other opening arrangement (not shown). The anvil 20" is moved between the open and fully clamped positions by the axial travel of the firing adapter 150 in the manner described above. Once the firing

31

adapter 150 has been advanced to the fully clamped position (FIG. 26), the surgeon may then advance the knife bar 172" distally in the manner described above. If the surgeon desires to use the end effector as a grasping device to manipulate tissue, the firing adapter may be moved proximally to allow the anvil 20" to move away from the elongated channel 14" as represented in FIG. 27 in broken lines. In this embodiment, as the knife bar 172" moves distally, the upper transverse member 173' and the lower transverse member 175' draw the anvil 20" and elongated channel 14" together to achieve the desired staple formation as the knife bar 172" is advanced distally through the end effector 12". See FIG. 28. Thus, in this embodiment, staple formation occurs simultaneously with tissue cutting, but the staples themselves may be sequentially formed as the knife bar 172" is driven distally.

FIGS. 29 and 30 illustrate use of an end effector 12" that has an anvil 20" that is fabricated from, for example, stainless steel, titanium, PGA (Polyglycolic acid) or other absorbable plastic and is somewhat flexible. These Figures also illustrate use of a retention matrix 6250 and an alignment matrix 6206 which will be discussed in further detail below. As can be seen in FIG. 29, the anvil 20" flexes into the fully formed position as the knife bar 172" is driven distally therethrough.

In many surgical applications, it is desirable or advantageous to employ a surgical cutting and stapling instrument that has an end effector that may be articulated relative to the elongated shaft assembly. The ability to access tight areas with prior articulatable instruments, however, was often times limited due to the size and construction of the members used to effect articulation of the end effector. FIGS. 31-40 illustrate another surgical instrument embodiment of the present invention that is capable of articulating the end effector relative to the elongated shaft and which employs a relatively compact articulation control arrangement in the handle assembly.

The surgical instrument 310 of this embodiment is substantially similar to the various surgical instrument embodiments 10 described above, except that this embodiment employs an articulated shaft assembly 312 to facilitate selective positioning of the end effector 12 relative to the elongated longitudinal axis A-A. While the surgical instrument 310 will be described herein for use in connection with an end effector 12 of the type described above, those of ordinary skill in the art will appreciate that the surgical instrument 310 may also be employed in connection with a second firing adapter 150 to actuate an end effector 12' or other end effector arrangements. As can be seen in FIGS. 31 and 32, the articulated shaft assembly 312 includes a distal shaft assembly portion 314 that is pivotally coupled to a proximal shaft assembly portion 316 that is operably coupled to the handle assembly 100. In various embodiments, for example, the distal shaft assembly 314 includes a distal spine member 320 that has a pair of trunion cradles 322 therein for receiving the trunions 17 therein. See FIG. 32. The distal spine member 320 has a proximal end 324 that includes a pivot base 326 that has a pivot pin 328 protruding therefrom.

As can be seen in FIG. 32, the proximal shaft assembly portion 316 includes a proximal spine segment 330 that has a proximal pivot base and knife guide 332 attached thereto. The knife guide 332 may, for example, be welded or attached to the proximal spine segment 330 with adhesive or other fastener arrangements. A pivot hole 334 is provided in the proximal pivot base knife guide 332 to rotatably receive the pivot pin 328 therein to enable the distal spine segment 320 to pivot relative to the proximal spine segment 330 about a first pivot axis FA-FA that is substantially transverse to the longitudinal axis A-A. The surgical instrument 310 further includes a distal firing tube segment 370 that is pivotally coupled to a

32

pair of firing tube links 380, 382 for pivotal travel about a second axis SA-SA. The distal firing tube segment 370 has a retainer hole 372 for receiving the retainer button 144 of the first firing adapter 140 therein. The pair of firing tube links 380, 382 are pivotally coupled to a proximal firing tube 390 for pivotal travel relative thereto about a third pivot axis TA-TA. See FIG. 32.

In various embodiments, the proximal firing tube 390 is attached to a rotation knob 400 that is rotatably attached to the handle assembly 100. See FIGS. 31, 38 and 39. The rotation knob 400 may be molded from a polymer or plastic material and include a hub portion 402 and flange portion 404 that is spaced from the hub portion 402. A nose portion 101 of the handle assembly 100 is received between the hub portion 402 and the flange portion 404 to enable the rotation knob 400 to be rotatable relative to the handle assembly 100 about longitudinal axis A-A. In other embodiments, the rotation knob 400 may be fabricated from other suitable materials. In the depicted embodiment, the proximal firing tube 390 and the proximal spine segment 330 are each non-movably attached to the rotation knob 400. As can be seen in FIGS. 38 and 39, the proximal spine segment 330 and the proximal firing tube 390 are pinned to the rotation knob 400 by a pin 406. Thus, the surgeon may rotate the end effector 12 relative to the handle housing 100 in a 360° path about the longitudinal axis A-A by rotating the rotation knob 400.

Referring to FIGS. 37, 38 and 40, in various embodiments, the end effector 12 may be selectively articulated relative to the longitudinal axis A-A by a pair of articulation members 420, 430 that are attached to the distal pivot base 326 and an articulation ball 440 that is rotatably supported within a socket 408 in the rotation knob 400. In various embodiments, the articulation members 420, 430 may comprise, for example, cables that are fabricated from multiwire cable, Nitinol, titanium, etc. The first or right articulation member 420 has a distal end 422 that has a lug 424 formed thereon that is sized to be press-fit into a first cable attachment hole 327 that is provided in the distal pivot base 326. Likewise, the second or left articulation member 430 has a distal end 432 that has a lug 434 formed thereon that is sized to be press-fit into a second cable attachment hole 329 that is provided in the distal pivot base 326. See FIG. 37. Thus, the end effector 12 may be pivoted to the right about first axis FA-FA (FIGS. 35 and 36) by pulling on the first or right articulation member 420 and the end effector 12 may be pivoted to the left about first axis FA-FA by pulling the second or left articulation member 430. In various embodiments, the right articulation member 420 may be slidably received within a right cable channel 336 formed in the proximal spine segment 330 and the left articulation member 430 may be slidably received within a left cable channel 338 in the proximal spine segment 330.

Turning to FIGS. 38-40, the first articulation member 420 has a proximal end 426 that has a retaining ball 428 swaged thereon or otherwise attached thereto that is adapted to be received within a first retaining slot 442 in the articulation ball 440 that is rotatably supported within a socket 401 in the rotation knob 400. Likewise, the second articulation member 430 has a proximal end 436 that has a retaining ball 438 swaged thereon or otherwise attached thereto that is adapted to be received within a second retaining slot 444 in the articulation ball 440. As can be most particularly seen in FIG. 40, the articulation ball 440 further has an actuator slot 446 therethrough that facilitates the unimpeded passage of the proximal firing tube segment 390 therein. As shown in FIG. 38, the actuator slot 446 may taper from wider opening portions 448, 450 to a passage 452 in the center of the articulation ball 440

that permits sliding passage of the proximal firing tube segment 390. As will be discussed further below, the articulation ball 440 is rotatably or pivotally supported within the socket 401 and is selectively movable from a neutral position (shown in FIG. 38 in solid lines) to first and second articulation control positions (shown in FIG. 38 in broken lines). The articulation ball 440 is also axially movable within the socket 401.

As can be seen in FIG. 40, the surgical instrument 310 may include a locking arrangement, generally designated as 453 for locking the articulation ball 440 in any one of the neutral, first and second articulation control positions. In various embodiments, the locking arrangement 453 comprises a series of locking detent segments 454 that are provided on the articulation ball 440 and are adapted to mate with locking ribs 410 that are formed within a recessed 408 formed in a hub portion 402 oriented within the socket area 401 of the rotation knob 400. An actuator passage 412 extends through the hub portion 402 and aligns with the actuator slot 446 in the articulation ball 440 to accommodate the proximal firing tube segment 390 therethrough. As can be seen in FIGS. 38 and 39, an actuator ball spring 456 is journaled on a spring retention hub 414 portion of the rotation knob 400 to it bias the articulation ball 440 proximally such that the locking detents 454 are brought into retaining engagement with the locking ribs 410 in the hub portion 402.

To facilitate application of articulation motions to the articulation ball 440, a pair of laterally extending articulation handles 458, 460 protrude from the articulation ball 440 in diametrically opposite directions. In various embodiments, the articulation ball 440 may be fabricated from, for example, polycarbonate, Nylon, Ultem®, with no fill, glass fill, carbon fill, mineral fill, etc. and have the locking detents 454 machined or molded thereon. The articulation handles 458, 460 may be attached to the articulation ball 440 by press fits, welds, etc. Such locking arrangement enables the articulation ball 440 to be locked in any of the neutral or first or second articulation positions. Once the surgeon has moved the articulation ball 440 to achieve the desired articulated position of the end effector, the surgeon may release the articulation ball 440 to enable the actuator ball spring 456 to bias the articulation ball 440 proximally such that the locking detents 454 are brought into retaining engagement with the locking ribs 410 in the hub portion 402. In various embodiments, the actuator ball spring 456 may be sized such that the articulation ball 440 may spring back to the neutral position when the articulated end effector is forcibly pulled back through a trocar or similar opening. Furthermore, use of the articulation handles 458, 460 enable the degree of articulation to be “tuned” to the particular surgical application.

As can be seen in FIG. 38, the first or right articulation handle 458 protrudes through a right slot 416 in the rotation knob 400 and the second or left articulation handle 460 protrudes through a left slot 418 in the rotation knob 400. To articulate the end effector 12 relative to the longitudinal axis A-A, the surgeon first moves the right and left articulation handles 458, 460 axially in the distal direction “DD” to disengage the locking detents 454 from the locking ribs 410 in the hub portion 402 of the rotation knob 400. Thereafter, the surgeon may pivot the articulation ball 440 by moving the articulation handles 458, 460 in the desired directions to apply articulation motions to the articulation members 420, 430. For example, the end effector 12 may be pivoted to the right by moving the right articulation handle 458 in the proximal direction “PD” and the left articulation handle 460 in the distal direction “DD” to apply a pulling motion (articulation motion) to the right articulation member 420 and a pushing

motion to the left articulation member 430. Similarly, the end effector 12 may be pivoted to the left by moving the left articulation handle 460 in the proximal direction “PD” and the right articulation handle 458 in the distal direction “DD” to apply a pulling motion (articulation motion) to the left articulation member 430 and a pushing motion to the right articulation member 420. The various ranges of motions of the right and left articulation handles 458, 460 are illustrated in broken lines in FIG. 38. In this way, the end effector 12 can be optimally positioned in a variety of angular positions, e.g., by angling clockwise or counterclockwise, without requiring rotation or other movement of the elongated shaft assembly 40. FIG. 35 shows the angle α which in various embodiments can be from 0° to 45°.

Various embodiments of the surgical instrument 310 include a knife bar 472 that is movably supported within the hollow proximal spine segment 330 and through a knife support slot 333 that tapers from a narrow proximal portion 335 to a wide distal portion 337 to enable the knife bar 472 to flex therearound to accommodate the articulation of the end effector 12 about the longitudinal axis A-A. See FIG. 37. In various embodiments, the knife bar 472 may be fabricated from, for example, 300 or 400 Series stainless steel and have a tissue cutting edge 476 formed on the distal end thereof. As can be further seen in FIG. 37, the knife bar 472 slidably passes through a knife slot 473 in the distal pivot base 326. A proximal end 478 of the knife bar 472 is attached to a knife rod 480 that extends through the proximal spine segment 330 to drivingly engage the firing transmission 190 as was described above. See FIG. 31. The retention pin 406 extends into a longitudinal slot 392 (FIG. 38) in the proximal firing tube segment 390 and through a hole 339 in the proximal spine segment 330 (FIG. 39) and into a longitudinal slot 482 in the knife rod 480 to enable the proximal firing tube segment 390 and the knife rod 480 to move axially relative to the proximal spine segment 330 and handle assembly 100. Thus, the surgeon may selectively operate the knife bar 472 to cut tissue by operating the knife advancement trigger 200 in the manner described above.

Various articulation arrangements are disclosed in U.S. Patent Application Ser. No. 12/775,809, entitled “Laparoscopic Devices With Articulating End Effectors”, to Frederick E. Shelton IV, filed May 7, 2010 and U.S. patent application Ser. No. 12/775,699, entitled “Bendable Shaft For Handle Positioning” to Frederick E. Shelton IV, et al., filed May 7, 2010, the disclosures of each being herein incorporated by reference in their respective entireties. FIGS. 41 and 42 illustrate an alternative articulated shaft assembly 490 that is substantially identical to the articulated shaft assembly 340 and is operated in substantially the same way except for the intermediate firing tube segment 492 which replaces the firing tube link 380 employed in the articulated shaft assembly 340. As can be seen in FIGS. 41 and 42, the intermediate firing tube segment 492 extends from the distal firing tube segment 370 to the proximal firing tube segment 390. In various embodiments, the intermediate firing tube segment 492 may be fabricated from Nylon, Isoplast®, or other flexible plastic. In various embodiments, the intermediate firing tube segment 492 has two longitudinally extending compression spine portions 494 from which a plurality of spaced rib segments 496 that are separated by spaces 498 extend to form a substantially hollow tube segment through which the other components of the spine assembly and knife bar may operably pass. The spine portions 494 are configured to transmit the compression motions from the proximal firing tube segment 390 to the distal firing tube segment 370 which are of sufficient magnitude to actuate the anvil 20 to a fully fired position while

35

enabling the end effector **12** to be selectively articulated relative to the longitudinal axis A-A. The intermediate firing tube segment **492** has a distal end portion **491** that is attached to the distal firing tube segment by, for example, pins, slotted bosses, snap features, etc. as well as proximal portion **493** that is attached to the proximal firing tube segment **390** by the same or similar means. In this embodiment, the end effector **12** can be optimally positioned in a variety of angular positions, e.g., by angling clockwise or counterclockwise, without requiring rotation or other movement of the elongated shaft assembly **490**. FIG. **42** shows the angle α which in various embodiments can be from 0° to 45° .

FIGS. **43-47** illustrate another surgical instrument embodiment of the present invention. The surgical instrument **510** of this embodiment is substantially similar to the surgical instrument embodiment **310** described above, except for the various differences discussed below. While the surgical instrument **510** will be described herein for use in connection with an end effector **12** of the type described above, those of ordinary skill in the art will appreciate that the surgical instrument may also be employed in connection with a second firing adapter **150** to actuate an end effector **12'** or it may be used in connection with other end effector arrangements. Various embodiments of the surgical instrument **510** include an articulated shaft assembly **512** to facilitate selective positioning of the end effector **12** relative to the longitudinal axis A-A. As can be seen in FIGS. **43** and **44**, the articulated shaft assembly **512** includes a distal spine member **520** that has a pair of trunion cradles **522** therein for receiving the trunions **17** therein. The distal spine member **520** has a proximal end **521** that is pivotally coupled to a distal end **531** of a proximal spine segment **530**. In particular, the proximal end **521** of the distal spine segment **520** has a pair of spaced distal spine lines **523** that support an articulation pin **524** that extends through the distal end **531** of the proximal spine segment **530** to define an articulation axis AA-AA that is substantially transverse to longitudinal axis A-A. See FIG. **46**.

In various embodiments of the present invention, the end effector **12** is articulatable to a variety of different orientations about the longitudinal axis A-A. For example, angle α' in FIG. **47** can range from 180° to 90° . The end effector **12** is articulated by means of at least one articulation member **550** that is coupled to an articulation link **540**. Articulation link **540** is pivotally coupled to the distal end **521** of the distal spine segment **520** by a distal pin **542**. See FIG. **43**. The articulation link **540** is pivotally coupled to the distal end **552** of the articulation rod **550** by an articulation rod pin **554** as shown in FIG. **46**. As can be seen in FIG. **43**, the articulation member **550** extends through the articulated shaft assembly **512** and has a proximal end **556** that extends into a rotation knob **560** that is rotatably coupled to the handle assembly **100**. The proximal end **556** of the articulation member **550** is coupled to an articulation control member or button **558** that is slidably coupled to the rotation knob **560** for selective axial travel relative thereto. Thus, axially sliding the articulation button **558** in the distal direction "DD" will cause the end effector **12** to pivot about the longitudinal axis A-A in the manner illustrated in FIG. **47**. To return the end effector to a starting unarticulated position wherein the end effector is coaxially aligned on the longitudinal axis A-A, the surgeon simply slides the actuator button **558** in the proximal direction "PD" on the rotation knob **560**.

As with some of the embodiments described above, the rotation knob **560** is non-rotatably coupled to a mounting bushing **570** that is rotatably affixed to the handle assembly **100**. See FIGS. **43** and **47**. The mounting bushing **570** has a proximal flange **572** and a distal flange **574** that define a

36

rotational groove **575** therebetween to rotatably receive a nose portion **101** of the handle assembly **100** therebetween. Such arrangement enables the mounting bushing **570** to rotate about longitudinal axis A-A relative to the handle assembly **100**. The proximal spine segment **530** is non-rotatably pinned or otherwise attached (welded, adhesive, etc.) to the mounting bushing **570** such that rotation of the rotation knob **560** about longitudinal axis A-A causes the end effector **12** to rotate about longitudinal axis A-A. It will be understood that such arrangement may facilitate rotation of the end effector **12** in a 360° path about the longitudinal axis A-A.

This embodiment also has a distal firing tube segment **580** that is coupled to the first firing adapter **140** and axially movable on the distal spine segment **520**. In particular, the retainer button **144** on the first firing adapter **140** is received within a retainer hole **581** in the distal firing tube segment **580** in the manner described above. The distal firing tube segment **580** is actuated by at least one firing member that is attached thereto. In a preferred embodiment, the distal firing tube segment **580** is actuated by a pair of firing bands **582**, **584** attached thereto. The firing bands **582**, **584** are attached to a band mount **585** coupled to a proximal firing tube segment **590** that is attached to the firing yoke **114** in the above-described manner. Also journaled on the proximal spine segment **530** and coupled to the rotation knob **560** for rotation therewith is a cover tube **592**. The proximal firing tube **590** and the band mount **585** are axially movable relative to the cover tube **592**. The firing bands **582**, **584** are slidably received within lateral band channels **526** in the distal spine member **520** as shown in FIG. **44C**. In various embodiments, the firing bands **582**, **584** each comprise a thin flexible member that may be fabricated from, for example, stainless steel and are each capable of pushing on the distal firing tube segment **580** to actuate or close the anvil **20** in the above-described manner to form the staples **32** in the implantable staple cartridge **30**. Actuation of the firing cables **582**, **584** is accomplished by pulling the firing trigger **130** in the above-described manners. Returning the firing trigger **130** to the starting position will pull on the firing cables **582**, **584** and cause the first firing adapter **140** to either pull the anvil **20** to an open position or to move to a position wherein a spring (not shown) biases the anvil **20** to the open position.

The surgical instrument **510** may further include a knife **534** that is movably supported within a knife support slot **528** in the distal spine segment **520**. See FIG. **44B**. In various embodiments, the knife bar **534** may be fabricated from, for example, 300 or 400 stainless steel, etc. and have a tissue cutting edge **535** formed on the distal end thereof. The knife bar **534** is attached to a knife band **536** that may be fabricated from 300 or 400 series stainless steel. The knife band may, for example, comprise 0.007 to 0.012 inch thick stainless steel band material that is more hardened than the rod. The knife cable **536** extends through the distal spine member **520** and the proximal spine segment **530** and is attached to a knife rod **480** that drivingly engages the firing transmission **190** as was described above. Thus, the surgeon may selectively operate the knife bar **534** to cut tissue by operating the knife advancement trigger **200** in the manner described above. Various embodiments may also employ a bellows-like cover member **594** to prevent dirt, tissue, debris, etc. from fouling the articulation joint. See FIG. **48**.

FIGS. **49-53** illustrate another surgical instrument embodiment of the present invention. The surgical instrument **610** of this embodiment is substantially similar to the surgical instrument embodiment **10** described above, except for the differences explained below. The surgical instrument **610** is configured to actuate an end effector **612** that has two movable

jaws **613**, **615**. In various embodiments, the end effector **612** is coupled to an elongated shaft assembly **655** that protrudes from a handle assembly **100**. See FIG. **49**. The elongated shaft assembly **655** includes an elongated spine assembly **658** and an elongated closure tube assembly **680** that is axially movable on the spine assembly **658** in the proximal and distal directions. As shown, the elongated shaft assembly **655** extends distally from the handle assembly **100** in a generally straight line along a longitudinal axis A-A. In various embodiments, the elongated shaft assembly **655** may be approximately 9 to 16 inches (approximately 228.8 mm to 406.4 mm) long. However, the elongated shaft assembly **655** may be provided in other lengths.

Referring to FIGS. **50** and **51**, in various embodiments, the lower jaw **613** of the end effector **612** comprises an elongated channel **614** and the upper jaw **615** comprises an anvil **620**. The elongated channel **614** has a pair of spaced side walls **616** that each terminate in an upwardly protruding closure end or tip **618**. The elongated channel **614** may be fabricated from, for example 17-4 or 400 series stainless steel and be sized to operably support a staple cartridge **630** or other form of staple cartridge therein. The anvil **620** may be fabricated from 416, 17-4, 17-7 stainless steel, etc. In at least one embodiment, for example, end effector **612** (when in a closed position) and the elongated shaft assembly **655** each have a maximum outer diameter that would permit the device to be operably passed through an opening that has a diameter of at least approximately 8-12 mm (approximately 0.31-0.47 inches). However, the end effector **612** and elongated shaft assembly **655** may have other diameters and shapes. The end effector **612** further includes a distal spine segment **660** that is adapted to be removably coupled to a distal end of a proximal spine segment **670** as will be further explained below.

The anvil **620** has a staple forming portion **622** that has a plurality of staple forming pockets formed therein. In addition, the anvil **620** has a bifurcated closure portion **624** that includes at least one and preferably a pair of downwardly extending closure tips **625**. As can be seen in FIGS. **50-53**, in at least one embodiment, the closure tips **625** and the corresponding closure ends or tips **618** of the elongated channel **614** are pivotally pinned to spine lugs **663** of a bifurcated distal end **662** of a distal spine segment **660** (FIG. **55**) of a spine assembly **658** by a pivot pin **626** such that, when viewed from the side, the closure tips **625** and closure tips **618** form a movable "scissors-like" closure structure generally designated as **628**. In other embodiments, the anvil **620** may be movably coupled to the elongated channel **614**.

Various embodiments of the end effector **612** also include an axially movable knife assembly **640** that includes a knife plate **642** that has a pair of spaced knife bars **644** protruding distally therefrom that are configured to slide axially between the spine lugs **663** of the distal spine segment **660**. See FIG. **55**. A knife member **646** is attached to, or otherwise formed on, the distal ends of the knife bars **644**. In various embodiments, the knife bars **644** and the knife member **646** may be fabricated from, for example, 300 or 400 Series stainless steel. A tissue cutting edge **648** is formed on a distal end of the knife member **646**. A lower portion **649** of the knife member **646** is configured to engage a staple driving sled **650** that is movably supported within the elongated shaft **614**. The staple driving sled **650** may be retained in a slot or slot arrangements (not shown) in the elongated channel **614** to facilitate axial movement of the staple driving sled **650** from a starting position (FIGS. **50-52**) to an end position (FIG. **53**) while remaining connected to the elongated channel **614**. The staple driving sled **650** has a staple driving surface or surfaces **652** thereon that are oriented to drivingly engage the staples **632** in

the staple cartridge **630** and drive the staples **632** upward toward the staple forming portion **622** of the anvil **620** as the knife member **646** is distally advanced through the end effector **612**.

Also in various embodiments, a distal spine nut **668** is rotatably coupled to the proximal end **664** of the distal spine segment **660** for rotational travel relative thereto about the longitudinal axis A-A. The distal spine nut **668** has a pair of inwardly extending trunions **669** that are sized to be received in corresponding trunion slots **674** in a distal end **672** of a proximal spine segment **670** that protrudes from the handle assembly **100** to enable the distal spine segment **660** to rotate relative to the proximal spine segment **670**. As can be seen in FIG. **49**, the proximal spine segment **670** is pinned to the rotation knob **70** (by pin **66**) that is rotatably mounted to the handle assembly **100** in the above-described manner to facilitate rotation of the end effector **612** about the longitudinal axis A-A in a 360° path.

As can also be seen in FIG. **49**, a flange **676** is formed on a proximal end **671** of the proximal spine segment **670**. The flange **676** is configured to be rotatably supported within a groove **106** formed by mating ribs **108** that protrude inwardly from each of the case members **102**, **104**. Such arrangement facilitates the attachment of the proximal spine segment **670** to the handle assembly **100** while enabling the proximal spine segment **670** to be rotated relative to the handle assembly **100** about the longitudinal axis A-A in a 360° path. The proximal closure tube segment **682** may be fabricated from a polymer or other suitable material and have a proximal end **683** that is attached to a firing yoke **114** that is constructed and movably mounted within the handle assembly **100** in the various manners described above. In various embodiments for example, the firing yoke **114** may be over-molded to the proximal end **683** of the proximal closure tube segment **682**. However, other fastener arrangements may be employed. As described above, the firing yoke **114** may be rotatably supported within a support collar **120** that is configured to move axially within the handle assembly **100**. As can be seen in FIG. **49**, a longitudinal slot **681** is provided through the proximal closure tube segment **682** to enable the spine pin **66** to extend therethrough into the proximal spine segment **670** while facilitating the axial travel of the proximal closure tube segment **682** on the distal spine segment **670**.

As can be seen in FIG. **49**, the firing trigger **130** has an upper portion **134** that is pivotally (pinned) to firing links **636**, **638** that are pivotally (pinned) to the support collar **120**. Thus, movement of the firing trigger **130** toward the pistol grip portion **107** of the handle assembly **100** will cause the firing yoke **114** and the proximal closure tube segment **682** to move in the proximal direction "PD" (shown in broken lines in FIG. **49**). Movement of the clamp and firing trigger **130** away from the pistol grip portion **107** of the handle assembly **100** will cause the firing yoke **114** and firing tube **110** to move in the proximal direction "DD" on the proximal spine segment **670**.

As can be seen in FIGS. **50-53**, the proximal closure tube segment **682** has a distal end **684** that is configured to be attached to a proximal end **692** of a distal closure tube segment **690**. In the illustrated embodiment, the distal closure tube segment **690** is configured to be threadably attached to the distal end **684** of the proximal closure tube segment **682**. The distal end **694** of the distal closure tube segment **690** has a tapered drive member **696** therein that is configured to interface with the scissors-like closure structure **628** such that when the distal closure tube segment **690** is in the position illustrated in FIG. **51**, an end effector spring or springs **617** positioned between the elongated channel **614** and the anvil **620** serves to bias the anvil **620** to the open position illustrated

in that Figure. However, when the distal closure tube segment **690** is pulled in the proximal direction “PD”, the tapered drive member **696** contacts the scissors-like closure structure **628** to pivot the jaws **613** (elongated channel **614**) and **615** (anvil **620**) towards each other. See FIGS. **52** and **53**.

The surgical instrument **610** may further include a knife advancement system **639** that includes knife rod **700** that extends through the proximal spine segment **670** and has a proximal end portion **702** that drivingly interfaces with a firing transmission **190** that is operably attached to a knife advance trigger **200** in the manner described above. Thus, the surgeon may advance the knife rod **700** distally by pulling the knife advancement trigger **200** as was described above. As can be seen in FIGS. **52** and **53**, the knife rod **700** has a bifurcated distal end **704** that includes an upper knife rod segment **706** and a lower knife rod segment **708** that are configured to engage the knife plate **642**. As can be seen in FIGS. **51-54**, the upper knife rod segment **706** is configured to slide through an upper slot **773** in the spine nut **668** and the lower knife rod segment **708** is configured to slide through a lower slot **775** in the spine nut **668**.

To use the surgical instrument **610**, the end effector **612** is attached to the distal end **672** of the proximal spine segment **670** by inserting the trunions **669** on the spine nut **668** into their corresponding trunion cradles **674** in the proximal spine segment **670**. See FIG. **50**. Thereafter, the surgeon or clinician may rotate the end effector **612** relative to the elongated shaft assembly **655** to thread the distal closure tube segment **690** onto the proximal closure tube segment **682** to form the closure tube assembly **680**. The end effector **612** may have the staple cartridge **630** therein or the clinician may install the staple cartridge into the elongated channel **614** at this or a later time. Once the end effector **612** has been attached to the elongated shaft assembly **655** of the surgical instrument **610**, the surgeon may insert the end effector **612** and elongated shaft assembly **655** through an access passage extending into the patient (e.g., through a trocar or endoscope, etc. or through an incision—in the case of open surgery) to grasp the target tissue between the end effector jaws **613**, **615**. As with various embodiments described above, the jaws **613**, **615** are closed by manipulating the firing trigger **130** relative to the pistol grip **107** of the handle assembly **100**. Once the target tissue has been grasped between the end effector jaws **613**, **615**, the surgeon may “fire” or form the staples **632** into the target tissue by compressing the anvil **620** into the staple cartridge **630** in the manner described above. If the procedure does not require the target tissue to be cut, the surgeon may then release the firing trigger **130** to permit the anvil **620** to move to the open position (under biasing motion from spring **617**) and thereby release the implantable staple cartridge **630** from the end effector **612**. The surgeon may then re-close the end effector jaws **613**, **615** to permit the end effector **612** to be withdrawn through an access passage or working channel. If, however, the surgeon desires to cut the target tissue between the lines of staples **632**, the surgeon may fire the knife assembly **640** by operating the knife advancement trigger **200** in the manner described above to drive the knife member **648** distally through the target tissue. As the knife member **648** moves distally through the end effector **612**, it contacts the staple driving sled **650** which serves to further drive the staples **632** into forming contact with the staple forming surface **622** of the anvil **620** to further form the staples **632**. See FIG. **53**. Thereafter, the surgeon may open the end effector **612** to release the cut/staple target tissue and implantable staple cartridge **630** therefrom.

Thus, the unique and novel closure tube arrangement which closes the jaws of the end effector by moving the

closure tube distally enables smaller closure structures to be employed while still maintaining the ability to generate large closure forces required to form staples. In addition, this embodiment of the present invention provides the surgeon with the flexibility to staple tissue with out cutting it in applications not requiring the tissue to be cut.

FIGS. **56-60** illustrate an alternative surgical instrument embodiment **810** that is substantially identical to the surgical instrument **610** described above, except for the differences discussed below. The surgical instrument **810**, for example, includes a flexible spine assembly **820** that has a proximal end with a flange **822** thereon that is rotatably received within a groove **106** formed by mating ribs **108** that protrude inwardly from each of the case members **102**, **104** forming the handle assembly **100**. See FIGS. **57** and **58**. Such mounting arrangement facilitates rotational travel of the flexible spine assembly **820** relative to the handle assembly **100**. In various embodiments, the flexible spine assembly **820** may be fabricated from, for example, Nylon, Acrylonitrile butadiene styrene (ABS), polycarbonate, liquid crystal polymer, stainless steel, titanium, etc. and may be configured for use with an end effector **612** of the type described above.

The surgical instrument **810** further includes an elongated shaft assembly generally represented by **830**. In various embodiments, for example, the elongated shaft assembly **830** includes a reconfigurable shaft segment **840** and a proximal shaft segment **844**. As can be seen in FIG. **56**, for example, the reconfigurable shaft segment **840** may have a distal mounting collar **842** that is non-movably attached to a portion of the flexible spine assembly **820** by, for example, adhesive, welding, fasteners, etc. The reconfigurable shaft segment **840** is selectively reconfigurable between a linear configuration wherein all portions of the reconfigurable segment **840** are substantially coaxially aligned with each other (i.e., they form a substantially straight hollow tubular structure) and configurations wherein at least one of the portions is not coaxially or linearly aligned with another portion of the reconfigurable segment **840**. In the embodiment depicted in FIG. **56**, for example, the reconfigurable shaft segment **840** may be fabricated from Nylon, Acrylonitrile butadiene styrene (ABS), polycarbonate, etc. and have a plurality of ribs **846** that facilitate the reconfiguration of the segment **840** from a linear or coaxial alignment orientation to non-linear or non-coaxial orientations (e.g., serpentine, curved, etc.) and remain in such orientations until the user reconfigures the shaft segment **840** by hand or through the use of other surgical instruments such as grasping devices and the like. Thus, the reconfigurable shaft segment **840** is “passively articulatable” meaning that the device is not equipped with articulation means for actively controlling the articulation of the segment **840**.

In various embodiments, the proximal shaft segment **844** is coupled to the reconfigurable shaft segment **840** by, for example, interlocking features or pins and serves to facilitate rotational attachment of the reconfigurable shaft segment **840** to the handle assembly **100**. In at least one embodiment, for example, the proximal shaft segment **844** is coupled to the mounting bushing **60** that is rotatably affixed to the handle assembly **100** as described hereinabove. See FIGS. **57** and **59**.

Also in various embodiments, a closure tube segment **832** is movably mounted on a portion of the flexible spine assembly **820** for selective movement thereon. See FIGS. **56** and **60**. As can be seen in FIG. **60**, in at least one embodiment, the closure tube segment **832** and the spine assembly **820** are formed with opposing flanged portions **833**, **821** respectively, such that the closure tube segment **832** is prevented from sliding off of the spine assembly **820** while remaining movably mounted thereon. In various embodiments, a flexible

closure member **848** is coupled to, or comprises a portion of, the firing yoke **114**. See FIGS. **57** and **59**. The flexible closure member **848** may be fabricated from, for example, stainless steel, etc. and have a distal end portion **849** that extends through an elongated slot **834** in the spine assembly **820** to be coupled to the closure tube segment **832**. Such arrangement facilitates movement of the closure tube segment **832** in the distal direction “DD” and proximal direction “PD” on the spine assembly **820** by actuating the firing trigger **130** in the manners described above.

As can be seen in FIG. **56**, the surgical instrument **810** may be employed with an end effector **612** which was described in detail above. In particular, the end effector **612** may be removably coupled to the flexible spine assembly **820** by inserting the trunions **669** on the spine nut **668** into corresponding trunion slots **825** in a distal end **825** of the spine assembly **820**. See FIG. **60**. A distal end **835** of the closure tube segment **832** is configured to be threadably attached to the proximal end **692** of the distal closure tube segment **690** in the above-described manner.

In at least one embodiment, the surgical instrument **810** further includes a knife advancement system **639** that includes knife rod **700** that extends through the spine assembly **820** and has a proximal end portion **702** that drivingly interfaces with a firing transmission **190** that is operably attached to a knife advance trigger **200** in the manner described above. Thus, the surgeon may advance the knife rod **700** distally by pulling the knife advancement trigger **200** as was described above. The knife rod **700** has a bifurcated distal end **704** that includes an upper knife rod segment **706** and a lower knife rod segment **708** that are configured to engage the knife plate **642** in the end effector **612**. See FIG. **60**.

To use the surgical instrument **810**, the end effector **612** is attached to the distal end **823** of the spine assembly **820** by inserting the trunions **669** on the spine nut **668** into their corresponding trunion cradles **825**. Thereafter, the surgeon or clinician may rotate the end effector **612** to thread the distal closure tube segment **690** onto the closure tube segment **832**. The end effector **612** may have the staple cartridge **630** therein or the clinician may install the staple cartridge into the elongated channel **614** at this time. Once the end effector **612** has been attached to the elongated closure tube assembly **830** of the surgical instrument **810**, the surgeon may configure the reconfigurable shaft segment **840** such that the elongated shaft assembly portions are coaxially aligned for insertion through an opening or working channel that extends into the patient (e.g., through a trocar or endoscope, etc. or through an incision—in the case of open surgery). Thereafter, the surgeon may reconfigure the reconfigurable shaft segment **840** such that portions thereof are not coaxially aligned with each other to orient the end effector **612** attached thereto in a desired position relative to the target tissue. As with various embodiments described above the jaws **613**, **615** are closed by manipulating the firing trigger **130** relative to the pistol grip **107** of the handle assembly **100**. Once the target tissue has been grasped between the end effector jaws **613**, **615**, the surgeon may “fire” or form the staples **632** into the target tissue by compressing the anvil **620** into the staple cartridge **630** in the manner described above. If the procedure does not require the target tissue to be cut, the surgeon may then release the firing trigger **130** to permit the anvil **620** to move to the open position (under biasing motion from spring **617**) and thereby release the implantable staple cartridge **630** from the end effector **612**. The surgeon may then re-close the end effector jaws **613**, **615** and reconfigure the reconfigurable shaft segment **840** to permit the end effector **612** to be withdrawn through an access passage or working channel. If,

however, the surgeon desires to cut the target tissue between the lines of staples **632**, the surgeon may fire the knife assembly **640** by operating the knife advancement trigger **200** in the manner described above to drive the knife member **648** distally through the target tissue. As the knife member **648** moves distally through the end effector **612**, it contacts the staple driving sled **650** which serves to further drive the staples **632** into forming contact with the staple forming surface **622** of the anvil **620** to further form the staples **632**. Thereafter, the surgeon may open the end effector **612** to release the cut/staple target tissue and implantable staple cartridge **630** therefrom.

FIGS. **61** and **62** illustrate another surgical instrument embodiment **810'** that is substantially identical to the surgical instrument **810** embodiment described above, except for the reconfigurable shaft segment **850** which comprises a portion of an elongated shaft assembly **830'** that is operably coupled to handle assembly **100** for operating an end effector **612**. In various embodiments, the reconfigurable shaft segment **850** comprises a plurality of movably interconnected tubular links **852**. Each tubular link **852** may be fabricated from, for example, Nylon, Acrylonitrile butadiene styrene (ABS), polycarbonate with or without glass or carbon fill, etc. and have a tubular body portion **854**. The tubular body portion **854** may have a sphere-like or ball-like coupler portion **856** formed thereon that has a spine-receiving passage **858** there-through. In addition, the tubular spine-receiving passage **858** extends into a hollow socket **860** formed in the tubular body portion **854** that is sized to movably receive the ball-like coupler portion **856** of an adjacent tubular link **852**. The ball-like coupler portions **856** are sized relative to the sockets **860** to permit the ball-like coupler portion **856** to be snapped therein and retained in a desired configuration wherein the shaft segment is in a substantially straight line to configurations wherein the shaft **850** may have a curved (FIG. **62**) or serpentine-like configuration (FIG. **61**).

While the ball-like coupler portions **856** and sockets **860** may be sized relative to each other to create a small amount of frictional force therebetween that can retain the segment **850** in a desired orientation until an external force is applied thereto, the embodiment depicted in FIGS. **60** and **61**, employs a locking system **862** to releasably retain or immovably lock the tubular links **852** together in a desired configuration. As can be seen in those Figures, the locking means **862** comprises at least one, and preferably a plurality of, flexible latch nubs or members **864** formed on the perimeter of the tubular link **852** adjacent one end **853** thereof. In a preferred embodiment, four latch nubs **864** are employed. Other embodiments could have 1, 2, 3 or more than four latch nubs **864**. Each tubular link **852** further comprises a locking member **866** that corresponds to each latch nub **864** adjacent the other end **865** of the link **852**. Each locking member **866** has a latch-receiving notch **868** therein configured to releasably receive a portion of the corresponding latch nub **864** formed on an adjacent tubular link **852** therein.

To use the surgical instrument **810'**, the end effector **612** is attached to the distal end **823** of the spine assembly **820** in the manner described above. The distal closure tube segment **690** of the end effector **612** is threaded onto the closure tube segment **832**. Once the end effector **612** has been attached to the elongated closure tube assembly **830** of the surgical instrument **810'**, the surgeon may configure the reconfigurable shaft segment **850** such that the elongated shaft assembly portions are coaxially aligned for insertion through an opening or working channel that extends into the patient (e.g., through a trocar or endoscope, etc. or through an incision—in the case of open surgery). Thereafter, the surgeon may

employ, for example, a grasping instrument **869** to configure the movable links **852** of the reconfigurable shaft segment **850** to a desired orientation and then press the appropriate locking nubs **864** on each link **852** into their corresponding latch receiving notch **868** to lock the links **852** in the desired orientation. See FIG. **62**. As with various embodiments described above, the jaws **613**, **615** are closed by manipulating the firing trigger **130** relative to the pistol grip **107** of the handle assembly **100**. Once the target tissue has been grasped between the end effector jaws **613**, **615**, the surgeon may “fire” or form the staples **632** into the target tissue by compressing the anvil **620** into the staple cartridge **630** in the manner described above. If the procedure does not require the target tissue to be cut, the surgeon may then release the firing trigger **130** to permit the anvil **620** to move to the open position (under biasing motion from spring **617**) and thereby release the implantable staple cartridge **630** from the end effector **612**. The surgeon may then re-close the end effector jaws **613**, **615** and use the grasping instrument **869** to remove the locking nubs **864** from their corresponding latch receiving notches **868** to permit the links **852** to be aligned in such a manner to permit the device to be withdrawn through an access passage or working channel. If, however, the surgeon desires to cut the target tissue between the lines of staples **632**, the surgeon may fire the knife assembly **640** by operating the knife advancement trigger **200** in the manner described above to drive the knife member **648** distally through the target tissue. As the knife member **648** moves distally through the end effector **612**, it contacts the staple driving sled **650** which serves to further drive the staples **632** into forming contact with the staple forming surface **622** of the anvil **620** to further form the staples **632**. Thereafter, the surgeon may open the end effector **612** to release the cut/stapled target tissue and implantable staple cartridge **630** therefrom.

FIGS. **63-68** illustrate another surgical instrument embodiment **810** that is substantially identical to the surgical instrument embodiments **810**, **810'** described above, except for the reconfigurable shaft segment **870** and related locking system **882** of the elongated shaft assembly. In various embodiments, the reconfigurable shaft segment **870** comprises a plurality of movably interconnected tubular links **872** and is coupled to a proximal shaft segment **871** that is coupled to the mounting bushing **60** rotatably supported within the handle assembly **100** as discussed in detail above. Each tubular link **872** may be fabricated from, for example, Nylon, Acrylonitrile butadiene styrene (ABS), polycarbonate, etc. and have a tubular body portion **874**. See FIG. **67**. The tubular body portion **874** may have a sphere-like or ball-like coupler portion **876** formed thereon that has a spine-receiving passage **878** extending therethrough. In addition, the tubular spine-receiving passage **878** extends into a hollow socket **880** formed in the tubular body portion **854** that is sized to movably receive the ball-like coupler portion **876** of an adjacent tubular link **872**. The ball-like coupler portions **876** are sized relative to the sockets **880** to permit the ball-like coupler portion **876** to be snapped therein and retained in a desired configuration wherein the reconfigurable shaft segment **870** is in a substantially straight line (FIG. **67**) to configurations wherein the shaft **870** may have a curved (FIG. **68**) or serpentine-like configuration.

While the ball-like coupler portions **876** and sockets **880** may be, in at least one embodiment, sized relative to each other to create a small amount of frictional force therebetween that can retain tubular links **872** of the reconfigurable shaft segment **870** in desired orientations until an external force is applied thereto, the embodiment depicted in FIGS. **63-68**, employs a locking system **882** for releasably retaining or immovably locking the tubular links **872** together in a

desired configuration. As can be seen in FIGS. **67** and **68**, the locking means **882** comprises at least one, and preferably two, selectively expandable locking bladders **884** that extend through the tubular links **872** in diametrically opposed positions. In various embodiments, the locking bladders **884** may be fabricated from, for example, Nylon film, etc. and be adapted to receive pressurized fluid from a source of pressurized fluid **886**. In the embodiment depicted in FIG. **64**, the source of pressurized fluid **886** comprises fluid pump arrangement **888** that is adapted to supply air under pressure into the locking bladders **884**. In particular, in at least one embodiment, the fluid pump arrangement **888** comprises a cylinder **889** that has a piston **890** therein. The piston **890** has an O-ring or other seal arrangement **891** around its perimeter and is attached to a threaded pump handle **892** that threadably engages a portion of the handle assembly **100**. Thus, by screwing the pump handle **892** into the handle assembly **100**, air in the cylinder **890** is pumped under pressure through a supply conduit **893** that extends from the cylinder **890** to a manifold assembly **894** that is received on the spine assembly **820**. The air pressure may be relieved in the locking bladders **884** by screwing the pump handle **894** in an opposite direction.

As can be seen in FIG. **65**, the manifold assembly **894** comprises an annular manifold area **895** that is sealed on each side by O-rings or other seals **896**. The annular manifold area **895** communicates with a supply line **897** that extends through the proximal shaft segment **871** and which is coupled for discharge into the locking bladders **884**. Such arrangement serves to supply pressurized air into the locking bladders **884** while facilitating the rotational travel of the spine assembly **820** about the longitudinal axis A-A relative to the handle assembly **100**. As used herein, the term pressurized fluid may comprise, for example, air, saline or preferably glycerine. In alternative embodiments, the tubular members may be filled with a very low durometer rubber or elastomer. When a pressure is applied to the rubber material, it will deform filling the voids and locking the shaft in much the same way as the fluid embodiment does.

To use the surgical instrument **810**, the end effector **612** is attached to the distal end **823** of the spine assembly **820'** in the manner described above. The distal closure tube segment **690** of the end effector **612** is threaded onto the closure tube segment **832**. Once the end effector **612** has been attached to the elongated shaft assembly **830** of the surgical instrument **810**, the surgeon may configure the reconfigurable shaft segment **870** such that the elongated shaft assembly portions **830** are coaxially aligned for insertion through an opening or working channel that extends into the patient (e.g., through a trocar or endoscope, etc. or through an incision—in the case of open surgery). Thereafter, the surgeon may employ, for example, a grasping instrument to configure the movable links **872** of the reconfigurable shaft segment **870** to a desired orientation. Once the reconfigurable shaft segment **870** has been oriented in a desired orientation, the surgeon may then screw in the pump handle **892** into the handle housing **100** to pressurize the locking bladders **884** to lock the movable links **872** in position as shown in FIG. **68**. As with various embodiments described above, the jaws **613**, **615** are closed by manipulating the firing trigger **130** relative to the pistol grip **107** of the handle assembly **100**. Once the target tissue has been grasped between the end effector jaws **613**, **615**, the surgeon may “fire” or form the staples **632** into the target tissue by compressing the anvil **620** into the staple cartridge **630** in the manner described above. If the procedure does not require the target tissue to be cut, the surgeon may then release the firing trigger **130** to permit the anvil **620** to move

to the open position (under biasing motion from spring 617) and thereby release the implantable staple cartridge 630 from the end effector 612. The surgeon may then re-close the end effector jaws 613, 615 and release the pressure in the locking bladders 884 by screwing the pump handle 892 in an opposite direction. A grasping instrument may be employed to manipulate the movable links 872 to a substantially coaxially aligned orientation (FIG. 67) or other orientation required to enable the device to be withdrawn from the patient. If, however, the surgeon desires to cut the target tissue between the lines of staples 632, the surgeon may fire the knife assembly 640 by operating the knife advancement trigger 200 in the manner described above to drive the knife member 648 distally through the target tissue. As the knife member 648 moves distally through the end effector 612, it contacts the staple driving sled 650 which serves to further drive the staples 632 into forming contact with the staple forming surface 622 of the anvil 620 to further form the staples 632. Thereafter, the surgeon may open the end effector 612 to release the cut/stapled target tissue and implantable staple cartridge 630 therefrom.

The various embodiments disclosed herein that include a reconfigurable shaft segment represent a vast improvement over traditional articulating surgical instrument arrangements that employ lockable articulation joints. Such surgical instruments are typically limited to 1 or 2 degrees of freedom for placement of the end effector at the transection site. The various embodiments of the present invention allow for a wider range of possible end effector positions and therefore provide the surgeon with much more flexibility when using the device through a single access port.

The unique and novel features of the various surgical staple cartridges and the surgical instruments of the present invention enable the staples in those cartridges to be arranged in one or more linear or non-linear lines. A plurality of such staple lines may be provided on each side of an elongated slot that is centrally disposed within the staple cartridge for receiving the tissue cutting member therethrough. In one arrangement, for example, the staples in one line may be substantially parallel with the staples in adjacent line(s) of staples, but offset therefrom. In still other embodiments, one or more lines of staples may be non-linear in nature. That is, the base of at least one staple in a line of staples may extend along an axis that is substantially transverse to the bases of other staples in the same staple line. For example, as will be discussed in further detail below, in alternative embodiments, the lines of staples on each side of the elongated slot may have a zigzag appearance. Such non-linear staple arrangements may be made possible due to the fact that the staples are not driven upwardly into the anvil. Instead in these various embodiments, the anvil is brought into forming contact with the tips of the non-moving staples. Such non-linear staple arrangements may attain better tissue fastening results with less staples than various linear staple arrangements employed in prior staple cartridges wherein the staples are actually driven upwardly into forming contact with the anvil.

FIG. 69 illustrates use of a surgical staple cartridge embodiment 900 in an end effector embodiment 612' of the present invention. The end effector 612' may be used in connection with the surgical instrument 610 in the various manners described above. The end effector 612' may be identical to end effector 612 as described above except for the differences described below. As can be seen in FIGS. 69 and 70, an embodiment of the surgical staple cartridge 900 has a cartridge body 902 that has a centrally disposed elongated slot 904 extending through a proximal end 903 to an area adjacent a distal end 605. The elongated slot 904 is configured to

permit knife body 646 of the surgical instrument 610 to axially move therethrough during a tissue cutting operation in the manner described above. In at least one embodiment, the cartridge body 902 consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose ("ORC") or a bio-absorbable foam fabricated from, for example, PGA (Polyglycolic acid, sold under the trademark Vicryl), PCL (polycaprolactone), PLA or PLLA (Polyactic acid), PDS, (Polydioxanone), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA and PDS in which lines 920, 930 of unformed staples 922 are supported. However, the cartridge body 902 may be fabricated from other materials that serve to support the unformed staples 922 in a desired orientation such that they may be compressed as the anvil 910 is brought into contact therewith. As with various other embodiments described above, the staple cartridge 900 is implantable and is left attached to the stapled tissue after the stapling procedure has been completed. In at least some embodiments, in order to prevent the staples 922 from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge 900 may be coated or wrapped in a biodegradable film 906 such as a polydioxanone film sold under the trademark PDS® or with a Polyglycerol sebacate (PGS) film or other biodegradable films fabricated from, for example, PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polyactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured. The cartridge body 902 of staple cartridge 900 is sized to be removably supported within the elongated channel 614 of the end effector 612'.

In the embodiment depicted in FIGS. 69, 73, and 74, the surgical staple cartridge 900 operably supports a first line 920 of staples 922 on one lateral side 907 of the elongated slot 904 and a second line 930 of staples 922 on the other lateral side 909 of the elongated slot 904. In various embodiments, the staples 922 may be fabricated from a metal material such as, for example, Titanium, Titanium alloys (e.g., 6Al-4V Titanium, 3Al-2.5V Titanium), Stainless Steel, etc. and have a staple base 924 and two upstanding staple legs 926 protruding therefrom. Each staple leg 926 may have a tissue-piercing tip 928 formed thereon. In the first line 920 of staples 922, the staple base 924 of at least one staple 922 overlaps the staple base of another staple 922. In a preferred embodiment, the staple base 924 of each staple 922 overlaps the staple bases 924 of two adjacent staples 922, except for the base 924 of the last staple 922 on each end of the first staple line 920. See FIG. 73. Thus, the first staple line 920 has a substantially non-linear shape. More particularly, when viewed from above, the first staple line 920 has a substantially zigzag appearance.

As can be seen in FIG. 72, the anvil 90 has two sequential longitudinal staple forming pockets 912 that each has a substantial zigzag shape that corresponds to the shape of the first line 920 of staples 922 such that, when the anvil 910 is brought into forming contact with the staples 922, the legs 926 thereof are formed as shown in FIG. 74. Thus, the distal leg of one staple shares the same pocket as the proximal leg of the next staple longitudinally. Such arrangement allows for a denser pocket pattern, even to a point where the staples themselves interact (e.g., are folded over one another). In prior staple pocket arrangements, in general, there has to be between 0.005 and 0.015 inches of metal/space from one set of pockets to the next. This embodiment of the present invention, however, has a spacing arrangement from 0 to 0.02

inches of interference/overlap (essentially a $-0.020''$) because one staple mates with the next staple, for example. Such arrangements allow for 15-30% more staples in the same space. Furthermore, when the staples interlock, there is less need for multiple lateral rows of staples. Prior arrangements commonly employ three rows on each side of the tissue cut line to prevent the existing of an open path through which blood may pass. Lines of interlocking staples are less likely to leave paths through which blood may pass. Another distinct advantage provided by the various interlocking staple arrangements of the present invention relates to improved “burst strength” which relates to the amount of force required to tear a staple line open.

Another staple forming pocket arrangement of the present invention may comprise a common staple forming pocket. As used herein, the term “common staple forming pocket” means that one forming pocket can form all of the staples in a single line of staples as opposed to prior anvil designs wherein a discrete forming pocket is provided for each leg of each staple to be formed.

FIG. 75 illustrates yet another staple embodiment 922' wherein the base 924' has an offset portion 928 to facilitate a tighter overlap of the bases 924'. As indicated above, the staple cartridge 900 has a second line 930 of staples 922 supported on a second lateral side 909 of the elongated slot 904. The second line 930 of staples 922 is substantially identical to the first line 920 of staples 922. Thus, the anvil 910 has a second common staple forming pocket 912 that corresponds to the second line of staples 930 for forming contact therewith. In alternative embodiments, however, the second line 930 of staples 922 may differ from the first line 920 of staples in shape and, perhaps, number of staples.

FIG. 71 illustrates a surgical staple cartridge 900' that is substantially identical to the staple cartridge 900 described above, with the exception of the lines 920', 930' of staples 922 supported therein. For example, in this embodiment, the line 920' of staples 922 are arranged relative to each other such that a base axis S-S of at least one staple base 924 is substantially transverse to the base axis S-S of the staple base 924 of at least one other adjacent staple 922. Such predetermined pattern of staples, when viewed from above, comprises a substantially zigzag arrangement. In the embodiment depicted in FIG. 76, the respective bases 924 of staples 922 may additionally have a base support member 927 overmolded thereon as shown. In various embodiments, the base support member 927 may be fabricated from, for example, non-absorbable plastic such as Polyether ether ketone “PEEK” or absorbable plastic such as, for example, Polyglycolic acid “PGA”, Polylactic acid “PLA” or “PLLA”, Polydioxanone “PDS”, PCL (polycaprolactone), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or various composite mixes of PGS, PDS, PLA, PGA, and PCL. The base support members 927 facilitate interlocking between the staples without making the staples themselves overlap. Thus, such arrangements could form staples with “B” shapes or inverted “W” shapes without the legs of the staples themselves overlapping. However, the crowns are connected by the base support members so they act like overlapping staples. Such arrangement allow the combined pockets to have two discrete paths for each leg.

The embodiment depicted in FIG. 77 employs a staple line 920'' wherein the legs 926 of adjacent staples 922 are coupled together by a coupler portion 929 molded or otherwise attached thereto. Each coupler portion 929 may be fabricated from, for example, Polyether ether ketone “PEEK” or absorbable plastic such as, for example, Polyglycolic acid “PGA”, Polylactic acid “PLA” or “PLLA”, Polydioxanone “PDS”,

PCL (polycaprolactone), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or various composite mixes of PGS, PDS, PLA, PGA, and PCL. Such staple line 920'' has substantial zigzag appearance when viewed from above. While the various surgical staple cartridge embodiments 900, 900' have been explained with reference to use with the end effectors 612' and the surgical stapling instrument 610, it will be understood that the staple cartridges 900, 900' may be effectively employed with the various other end effectors and surgical instruments described hereinabove, with appropriate staple forming pocket arrangements being provided in the anvils of those instruments in order to achieved the desired amount of staple formation upon movement of the anvils into forming contact with the staples.

FIGS. 78 and 79 illustrate another surgical staple cartridge 940 embodiment supported in an elongated channel 14 of a surgical instrument 10 of the present invention. In at least one embodiment, the surgical staple cartridge 940 includes a cartridge body 942 that has a centrally disposed elongated slot 944 extending at least partially therethrough. The elongated slot 944 is configured to permit a knife body of the surgical instrument 10 to axially move therethrough during a tissue cutting operation in the manner described above. In various embodiments, the cartridge body 942 consists of a compressible hemostat material such as, for example, oxidized regenerated cellulose (“ORC”) or a bio-absorbable foam of the types described above or below in which lines 946, 948, 950, 952 of unformed staples 922 are supported. In at least some embodiments, in order to prevent the staples 922 from being affected and the hemostat material from being activated during the introduction and positioning process, the entire cartridge 940 may be coated or wrapped in a biodegradable film 954 such as a polydioxanone film sold under the trademark PDS® or with a Polyglycerol sebacate (PGS) film or other biodegradable films fabricated from, for example, PGA (Polyglycolic acid, marketed under the trade mark Vicryl), PCL (Polycaprolactone), PLA or PLLA (Polylactic acid), PHA (polyhydroxyalkanoate), PGCL (poliglecaprone 25, sold under the trademark Monocryl) or a composite of PGA, PCL, PLA, PDS that would be impermeable until ruptured.

In the embodiment depicted in FIG. 78, the cartridge 940 further includes a cartridge support member 960 that is coupled to the cartridge body 942. In various embodiments, the cartridge support member 960 may be fabricated from a rigid material such as, for example, Titanium, Stainless Steel, Aluminum, any alloy of the foregoing, etc. and may be partially embedded within the cartridge body 942. In various embodiments, the cartridge support member 960 may be held in place by, for example, film 954. In still other embodiments wherein a limited bond is desired, sporadic use of cyanoacrylate could be used to “glue” the two components together. In yet other embodiments, the cartridge body 942 may be heated and “welded” or “fused” to the cartridge support member 960. In various embodiments, the cartridge support member 960 forms at least a portion of the bottom surface of the cartridge body 942 for mating with the elongated channel 14. In a preferred embodiment, the cartridge support member 960 has one or more snap features 962 protruding therefrom for releasably coupling the cartridge support member 960 to the elongated channel 14. Other forms of snap features/fastener arrangements may be employed for releasably coupling the cartridge support member 960 to the elongated channel 14.

In various embodiments, the cartridge support member 960 has a series of support ridges 964, 966, 968, 970, 972, 974, 976 formed thereon to provide some lateral support to the bases 924 of the staples 922 in the staple lines 946, 948, 950,

952 as shown in FIG. 78. Thus, in at least some embodiments, the support ridges are substantially coextensive with the staple lines. FIG. 80 illustrates an alternative staple cartridge embodiment 940' that is substantially identical to cartridge 940, except for the inclusion of upstanding fin portions 978, 979, 980, 981, 982, 983 that protrude from the support ridges 964, 966, 968, 970, 972, 976, respectively to provide additional lateral support to the staples 922. In various embodiments, the fin portions may be integrally formed with the cartridge support member 960 and have a height that is about 1/2 or less of the height of the cartridge. Thus, in preferred embodiments, for example, any standing features supporting the foam cannot extend above the maximum compression height of the foam. Thus, if the cartridge is designed, for example, to compress to 1/3 of its original height when fired, the fins would be between 66% of the uncompressed height, all the way down to 10% of uncompressed height.

In use, once the staples 922 have been formed through contact with the anvil 20 in the manner described above, the anvil 20 is opened and the end effector 12 is pulled away from the stapled tissue. As the end effector 12 is pulled away from the stapled tissue, the cartridge body 942 remains fastened to the stapled tissue and is then separated from the cartridge support member 960 which remains coupled to the elongated channel 14. In various embodiments, the cartridge support member 960 is provided with a color that differs from the color of the material comprising the cartridge body 942 as well as the color of the elongated channel 14. Such arrangement provides the surgeon with an easily recognizable indication that no staple cartridge is present within the end effector. Thus, the surgeon will not inadvertently attempt to reinsert/use the end effector without first installing a new staple cartridge therein. To do so, the surgeon simply disconnects the snap features of the cartridge support member 960 from the elongated channel 14 to enable the cartridge support member 960 of a new staple cartridge 940 to be placed therein. While the staple cartridges 940, 940' have been explained with reference to surgical instrument 10, it will be understood that those cartridges may be effectively employed with many of the other surgical instrument embodiments disclosed herein without departing from the spirit and scope of the present invention.

FIGS. 81 and 82 illustrate use of a surgical instrument embodiment 10 in connection with an end effector 990 that is substantially identical to end effector 12 described above except for a closure lockout arrangement 991 that is movably coupled to or otherwise supported within the elongated channel 14. In various embodiments, the closure lockout arrangement 991 includes a lockout arm 992 that has a distal end 993 and a proximal end 994. The lockout arm 992 is pivotally coupled to the elongated channel about a pivot member or trunion 995. The distal end portion has a leaf spring 996 or other biasing member attached thereto to bias the lockout arm 992 into an actuated or locking position wherein the proximal end portion 994 engages the distal end 141 of the first firing collar 141 to prevent the first firing collar 140 to be distally advanced to a "fired" position. However, when a staple cartridge 30 is installed in the elongated channel 14, the staple cartridge 30 causes the lockout arm 992 to move into an unactuated or unlocked position such that the firing collar 140 may be advanced distally past the lockout arm 992 to complete the staple firing process. See FIG. 81.

When in the locked position, the firing collar 140 cannot be advanced distally to complete the firing process. In addition, the firing trigger 130 cannot be advanced to the fully fired position wherein the knife lockout bar 210 is moved to an unlocked position to thereby enable the surgeon to advance

the knife bar 172. Thus, when there is no cartridge present within the end effector 990, the closure lockout arrangement 991 is in the locked position which ultimately prevents the knife bar 172 from being advanced. As such, the surgeon is unable to advance the knife bar 172 to cut tissue unless a cartridge 30 is present within the end effector 990. It will be understood that the closure lockout arrangement 991 as described above may be effectively incorporated into many of the surgical instrument embodiments disclosed herein without departing from the spirit and scope of the present invention.

In various embodiments, a staple cartridge can comprise a cartridge body and a plurality of staples stored within the cartridge body. In use, the staple cartridge can be introduced into a surgical site and positioned on a side of the tissue being treated. In addition, a staple-forming anvil can be positioned on the opposite side of the tissue. In various embodiments, the anvil can be carried by a first jaw and the staple cartridge can be carried by a second jaw, wherein the first jaw and/or the second jaw can be moved toward the other. Once the staple cartridge and the anvil have been positioned relative to the tissue, the staples can be ejected from the staple cartridge body such that the staples can pierce the tissue and contact the staple-forming anvil. Once the staples have been deployed from the staple cartridge body, the staple cartridge body can then be removed from the surgical site. In various embodiments disclosed herein, a staple cartridge, or at least a portion of a staple cartridge, can be implanted with the staples. In at least one such embodiment, as described in greater detail further below, a staple cartridge can comprise a cartridge body which can be compressed, crushed, and/or collapsed by the anvil when the anvil is moved from an open position into a closed position. When the cartridge body is compressed, crushed, and/or collapsed, the staples positioned within the cartridge body can be deformed by the anvil. Alternatively, the jaw supporting the staple cartridge can be moved toward the anvil into a closed position. In either event, in various embodiments, the staples can be deformed while they are at least partially positioned within the cartridge body. In certain embodiments, the staples may not be ejected from the staple cartridge while, in some embodiments, the staples can be ejected from the staple cartridge along with a portion of the cartridge body.

Referring now to FIGS. 83A-83D, a compressible staple cartridge, such as staple cartridge 1000, for example, can comprise a compressible, implantable cartridge body 1010 and, in addition, a plurality of staples 1020 positioned in the compressible cartridge body 1010, although only one staple 1020 is depicted in FIGS. 83A-83D. FIG. 83A illustrates the staple cartridge 1000 supported by a staple cartridge support, or staple cartridge channel, 1030, wherein the staple cartridge 1000 is illustrated in an uncompressed condition. In such an uncompressed condition, the anvil 1040 may or may not be in contact with the tissue T. In use, the anvil 1040 can be moved from an open position into contact with the tissue T as illustrated in FIG. 83B and position the tissue T against the cartridge body 1010. Even though the anvil 1040 can position the tissue T against a tissue-contacting surface 1019 of staple cartridge body 1010, referring again to FIG. 83B, the staple cartridge body 1010 may be subjected to little, if any, compressive force or pressure at such point and the staples 1020 may remain in an unformed, or unfired, condition. As illustrated in FIGS. 83A and 83B, the staple cartridge body 1010 can comprise one or more layers and the staple legs 1021 of staples 1020 can extend upwardly through these layers. In various embodiments, the cartridge body 1010 can comprise a first layer 1011, a second layer 1012, a third layer 1013,

51

wherein the second layer **1012** can be positioned intermediate the first layer **1011** and the third layer **1013**, and a fourth layer **1014**, wherein the third layer **1013** can be positioned intermediate the second layer **1012** and the fourth layer **1014**. In at least one embodiment, the bases **1022** of the staples **1020** can be positioned within cavities **1015** in the fourth layer **1014** and the staple legs **1021** can extend upwardly from the bases **1022** and through the fourth layer **1014**, the third layer **1013**, and the second layer **1012**, for example. In various embodiments, each deformable leg **1021** can comprise a tip, such as sharp tip **1023**, for example, which can be positioned in the second layer **1012**, for example, when the staple cartridge **1000** is in an uncompressed condition. In at least one such embodiment, the tips **1023** may not extend into and/or through the first layer **1011**, wherein, in at least one embodiment, the tips **1023** may not protrude through the tissue-contacting surface **1019** when the staple cartridge **1000** is in an uncompressed condition. In certain other embodiments, the sharp tips **1023** may be positioned in the third layer **1013**, and/or any other suitable layer, when the staple cartridge is in an uncompressed condition. In various alternative embodiments, a cartridge body of a staple cartridge may have any suitable number of layers such as less than four layers or more than four layers, for example.

In various embodiments, as described in greater detail below, the first layer **1011** can be comprised of a buttress material and/or plastic material, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example, and the second layer **1012** can be comprised of a bioabsorbable foam material and/or a compressible hemostatic material, such as oxidized regenerated cellulose (ORC), for example. In various embodiments, one or more of the first layer **1011**, the second layer **1012**, the third layer **1013**, and the fourth layer **1014** may hold the staples **1020** within the staple cartridge body **1010** and, in addition, maintain the staples **1020** in alignment with one another. In various embodiments, the third layer **1013** can be comprised of a buttress material, or a fairly incompressible or inelastic material, which can be configured to hold the staple legs **1021** of the staples **1020** in position relative to one another. Furthermore, the second layer **1012** and the fourth layer **1014**, which are positioned on opposite sides of the third layer **1013**, can stabilize, or reduce the movement of, the staples **1020** even though the second layer **1012** and the fourth layer **1014** can be comprised of a compressible foam or elastic material. In certain embodiments, the staple tips **1023** of the staple legs **1021** can be at least partially embedded in the first layer **1011**. In at least one such embodiment, the first layer **1011** and the third layer **1013** can be configured to co-operatively and firmly hold the staple legs **1021** in position. In at least one embodiment, the first layer **1011** and the third layer **1013** can each be comprised of a sheet of bioabsorbable plastic, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example, and the second layer **1012** and the fourth layer **1014** can each be comprised of at least one hemostatic material or agent.

Although the first layer **1011** can be compressible, the second layer **1012** can be substantially more compressible than the first layer **1011**. For example, the second layer **1012** can be about twice as compressible, about three times as compressible, about four times as compressible, about five times as compressible, and/or about ten times as compressible, for example, as the first layer **1011**. Stated another way,

52

the second layer **1012** may compress about two times, about three times, about four times, about five times, and/or about ten times as much as first layer **1011**, for a given force. In certain embodiments, the second layer **1012** can be between about twice as compressible and about ten times as compressible, for example, as the first layer **1011**. In at least one embodiment, the second layer **1012** can comprise a plurality of air voids defined therein, wherein the amount and/or size of the air voids in the second layer **1012** can be controlled in order to provide a desired compressibility of the second layer **1012**. Similar to the above, although the third layer **1013** can be compressible, the fourth layer **1014** can be substantially more compressible than the third layer **1013**. For example, the fourth layer **1014** can be about twice as compressible, about three times as compressible, about four times as compressible, about five times as compressible, and/or about ten times as compressible, for example, as the third layer **1013**. Stated another way, the fourth layer **1014** may compress about two times, about three times, about four times, about five times, and/or about ten times as much as third layer **1013**, for a given force. In certain embodiments, the fourth layer **1014** can be between about twice as compressible and about ten times as compressible, for example, as the third layer **1013**. In at least one embodiment, the fourth layer **1014** can comprise a plurality of air voids defined therein, wherein the amount and/or size of the air voids in the fourth layer **1014** can be controlled in order to provide a desired compressibility of the fourth layer **1014**. In various circumstances, the compressibility of a cartridge body, or cartridge body layer, can be expressed in terms of a compression rate, i.e., a distance in which a layer is compressed for a given amount of force. For example, a layer having a high compression rate will compress a larger distance for a given amount of compressive force applied to the layer as compared to a layer having a lower compression rate. This being said, the second layer **1012** can have a higher compression rate than the first layer **1011** and, similarly, the fourth layer **1014** can have a higher compression rate than the third layer **1013**. In various embodiments, the second layer **1012** and the fourth layer **1014** can be comprised of the same material and can comprise the same compression rate. In various embodiments, the second layer **1012** and the fourth layer **1014** can be comprised of materials having different compression rates. Similarly, the first layer **1011** and the third layer **1013** can be comprised of the same material and can comprise the same compression rate. In certain embodiments, the first layer **1011** and the third layer **1013** can be comprised of materials having different compression rates.

As the anvil **1040** is moved toward its closed position, the anvil **1040** can contact tissue T and apply a compressive force to the tissue T and the staple cartridge **1000**, as illustrated in FIG. 83C. In such circumstances, the anvil **1040** can push the top surface, or tissue-contacting surface **1019**, of the cartridge body **1010** downwardly toward the staple cartridge support **1030**. In various embodiments, the staple cartridge support **1030** can comprise a cartridge support surface **1031** which can be configured to support the staple cartridge **1000** as the staple cartridge **1000** is compressed between the cartridge support surface **1031** and the tissue-contacting surface **1041** of anvil **1040**. Owing to the pressure applied by the anvil **1040**, the cartridge body **1010** can be compressed and the anvil **1040** can come into contact with the staples **1020**. More particularly, in various embodiments, the compression of the cartridge body **1010** and the downward movement of the tissue-contacting surface **1019** can cause the tips **1023** of the staple legs **1021** to pierce the first layer **1011** of cartridge body **1010**, pierce the tissue T, and enter into forming pockets **1042** in the anvil **1040**. As the cartridge body **1010** is further com-

53

pressed by the anvil 1040, the tips 1023 can contact the walls defining the forming pockets 1042 and, as a result, the legs 1021 can be deformed or curled inwardly, for example, as illustrated in FIG. 83C. As the staple legs 1021 are being deformed, as also illustrated in FIG. 83C, the bases 1022 of the staples 1020 can be in contact with or supported by the staple cartridge support 1030. In various embodiments, as described in greater detail below, the staple cartridge support 1030 can comprise a plurality of support features, such as staple support grooves, slots, or troughs 1032, for example, which can be configured to support the staples 1020, or at least the bases 1022 of the staples 1020, as the staples 1020 are being deformed. As also illustrated in FIG. 83C, the cavities 1015 in the fourth layer 1014 can collapse as a result of the compressive force applied to the staple cartridge body 1010. In addition to the cavities 1015, the staple cartridge body 1010 can further comprise one or more voids, such as voids 1016, for example, which may or may not comprise a portion of a staple positioned therein, that can be configured to allow the cartridge body 1010 to collapse. In various embodiments, the cavities 1015 and/or the voids 1016 can be configured to collapse such that the walls defining the cavities and/or walls deflect downwardly and contact the cartridge support surface 1031 and/or contact a layer of the cartridge body 1010 positioned underneath the cavities and/or voids.

Upon comparing FIG. 83B and FIG. 83C, it is evident that the second layer 1012 and the fourth layer 1014 have been substantially compressed by the compressive pressure applied by the anvil 1040. It may also be noted that the first layer 1011 and the third layer 1013 have been compressed as well. As the anvil 1040 is moved into its closed position, the anvil 1040 may continue to further compress the cartridge body 1010 by pushing the tissue-contacting surface 1019 downwardly toward the staple cartridge support 1030. As the cartridge body 1010 is further compressed, the anvil 1040 can deform the staples 1020 into their completely-formed shape as illustrated in FIG. 83D. Referring to FIG. 83D, the legs 1021 of each staple 1020 can be deformed downwardly toward the base 1022 of each staple 1020 in order to capture at least a portion of the tissue T, the first layer 1011, the second layer 1012, the third layer 1013, and the fourth layer 1014 between the deformable legs 1021 and the base 1022. Upon comparing FIGS. 83C and 83D, it is further evident that the second layer 1012 and the fourth layer 1014 have been further substantially compressed by the compressive pressure applied by the anvil 1040. It may also be noted upon comparing FIGS. 83C and 83D that the first layer 1011 and the third layer 1013 have been further compressed as well. After the staples 1020 have been completely, or at least sufficiently, formed, the anvil 1040 can be lifted away from the tissue T and the staple cartridge support 1030 can be moved away, and/or detached from, the staple cartridge 1000. As depicted in FIG. 83D, and as a result of the above, the cartridge body 1010 can be implanted with the staples 1020. In various circumstances, the implanted cartridge body 1010 can support the tissue along the staple line. In some circumstances, a hemostatic agent, and/or any other suitable therapeutic medicament, contained within the implanted cartridge body 1010 can treat the tissue over time. A hemostatic agent, as mentioned above, can reduce the bleeding of the stapled and/or incised tissue while a bonding agent or tissue adhesive can provide strength to the tissue over time. The implanted cartridge body 1010 can be comprised of materials such as ORC (oxidized regenerated cellulous), protein matrix, polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25

54

(PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In certain circumstances, the cartridge body 1010 can comprise an antibiotic and/or anti-microbial material, such as colloidal silver and/or triclosan, for example, which can reduce the possibility of infection in the surgical site.

In various embodiments, the layers of the cartridge body 1010 can be connected to one another. In at least one embodiment, the second layer 1012 can be adhered to the first layer 1011, the third layer 1013 can be adhered to the second layer 1012, and the fourth layer 1014 can be adhered to the third layer 1013 utilizing at least one adhesive, such as fibrin and/or protein hydrogel, for example. In certain embodiments, although not illustrated, the layers of the cartridge body 1010 can be connected together by interlocking mechanical features. In at least one such embodiment, the first layer 1011 and the second layer 1012 can each comprise corresponding interlocking features, such as a tongue and groove arrangement and/or a dovetail joint arrangement, for example. Similarly, the second layer 1012 and the third layer 1013 can each comprise corresponding interlocking features while the third layer 1013 and the fourth layer 1014 can each comprise corresponding interlocking features. In certain embodiments, although not illustrated, the staple cartridge 1000 can comprise one or more rivets, for example, which can extend through one or more layers of the cartridge body 1010. In at least one such embodiment, each rivet can comprise a first end, or head, positioned adjacent to the first layer 1011 and a second head positioned adjacent to the fourth layer 1014 which can be either assembled to or formed by a second end of the rivet. Owing to the compressible nature of the cartridge body 1010, in at least one embodiment, the rivets can compress the cartridge body 1010 such that the heads of the rivets can be recessed relative to the tissue-contacting surface 1019 and/or the bottom surface 1018 of the cartridge body 1010, for example. In at least one such embodiment, the rivets can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In certain embodiments, the layers of the cartridge body 1010 may not be connected to one another other than by the staples 1020 contained therein. In at least one such embodiment, the frictional engagement between the staple legs 1021 and the cartridge body 1010, for example, can hold the layers of the cartridge body 1010 together and, once the staples have been formed, the layers can be captured within the staples 1020. In certain embodiments, at least a portion of the staple legs 1021 can comprise a roughened surface or rough coating which can increase the friction forces between the staples 1020 and the cartridge body 1010.

As described above, a surgical instrument can comprise a first jaw including the staple cartridge support 1030 and a second jaw including the anvil 1040. In various embodiments, as described in greater detail further below, the staple cartridge 1000 can comprise one or more retention features which can be configured to engage the staple cartridge support 1030 and, as a result, releasably retain the staple cartridge 1000 to the staple cartridge support 1030. In certain embodiments, the staple cartridge 1000 can be adhered to the staple cartridge support 1030 by at least one adhesive, such as fibrin and/or protein hydrogel, for example. In use, in at least one circumstance, especially in laparoscopic and/or endoscopic

surgery, the second jaw can be moved into a closed position opposite the first jaw, for example, such that the first and second jaws can be inserted through a trocar into a surgical site. In at least one such embodiment, the trocar can define an approximately 5 mm aperture, or cannula, through which the first and second jaws can be inserted. In certain embodiments, the second jaw can be moved into a partially-closed position intermediate the open position and the closed position which can allow the first and second jaws to be inserted through the trocar without deforming the staples 1020 contained in the staple cartridge body 1010. In at least one such embodiment, the anvil 1040 may not apply a compressive force to the staple cartridge body 1010 when the second jaw is in its partially-closed intermediate position while, in certain other embodiments, the anvil 1040 can compress the staple cartridge body 1010 when the second jaw is in its partially-closed intermediate position. Even though the anvil 1040 can compress the staple cartridge body 1010 when it is in such an intermediate position, the anvil 1040 may not sufficiently compress the staple cartridge body 1010 such that the anvil 1040 comes into contact with the staples 1020 and/or such that the staples 1020 are deformed by the anvil 1040. Once the first and second jaws have been inserted through the trocar into the surgical site, the second jaw can be opened once again and the anvil 1040 and the staple cartridge 1000 can be positioned relative to the targeted tissue as described above.

In various embodiments, referring now to FIGS. 84A-84D, an end effector of a surgical stapler can comprise an implantable staple cartridge 1100 positioned intermediate an anvil 1140 and a staple cartridge support 1130. Similar to the above, the anvil 1140 can comprise a tissue-contacting surface 1141, the staple cartridge 1100 can comprise a tissue-contacting surface 1119, and the staple cartridge support 1130 can comprise a support surface 1131 which can be configured to support the staple cartridge 1100. Referring to FIG. 84A, the anvil 1140 can be utilized to position the tissue T against the tissue contacting surface 1119 of staple cartridge 1100 without deforming the staple cartridge 1100 and, when the anvil 1140 is in such a position, the tissue-contacting surface 1141 can be positioned a distance 1101a away from the staple cartridge support surface 1131 and the tissue-contacting surface 1119 can be positioned a distance 1102a away from the staple cartridge support surface 1131. Thereafter, as the anvil 1140 is moved toward the staple cartridge support 1130, referring now to FIG. 84B, the anvil 1140 can push the top surface, or tissue-contacting surface 1119, of staple cartridge 1100 downwardly and compress the first layer 1111 and the second layer 1112 of cartridge body 1110. As the layers 1111 and 1112 are compressed, referring again to FIG. 84B, the second layer 1112 can be crushed and the legs 1121 of staples 1120 can pierce the first layer 1111 and enter into the tissue T. In at least one such embodiment, the staples 1120 can be at least partially positioned within staple cavities, or voids, 1115 in the second layer 1112 and, when the second layer 1112 is compressed, the staple cavities 1115 can collapse and, as a result, allow the second layer 1112 to collapse around the staples 1120. In various embodiments, the second layer 1112 can comprise cover portions 1116 which can extend over the staple cavities 1115 and enclose, or at least partially enclose, the staple cavities 1115. FIG. 84B illustrates the cover portions 1116 being crushed downwardly into the staple cavities 1115. In certain embodiments, the second layer 1112 can comprise one or more weakened portions which can facilitate the collapse of the second layer 1112. In various embodiments, such weakened portions can comprise score marks, perforations, and/or thin cross-sections, for example, which can facilitate a controlled collapse

of the cartridge body 1110. In at least one embodiment, the first layer 1111 can comprise one or more weakened portions which can facilitate the penetration of the staple legs 1121 through the first layer 1111. In various embodiments, such weakened portions can comprise score marks, perforations, and/or thin cross-sections, for example, which can be aligned, or at least substantially aligned, with the staple legs 1121.

When the anvil 1140 is in a partially closed, unfired position, referring again to FIG. 84A, the anvil 1140 can be positioned a distance 1101a away from the cartridge support surface 1131 such that a gap is defined therebetween. This gap can be filled by the staple cartridge 1100, having a staple cartridge height 1102a, and the tissue T. As the anvil 1140 is moved downwardly to compress the staple cartridge 1100, referring again to FIG. 84B, the distance between the tissue contacting surface 1141 and the cartridge support surface 1131 can be defined by a distance 1101b which is shorter than the distance 1101a. In various circumstances, the gap between the tissue-contacting surface 1141 of anvil 1140 and the cartridge support surface 1131, defined by distance 1101b, may be larger than the original, undeformed staple cartridge height 1102a. As the anvil 1140 is moved closer to the cartridge support surface 1131, referring now to FIG. 84C, the second layer 1112 can continue to collapse and the distance between the staple legs 1121 and the forming pockets 1142 can decrease. Similarly, the distance between the tissue-contacting surface 1141 and the cartridge support surface 1131 can decrease to a distance 1101c which, in various embodiments, may be greater than, equal to, or less than the original, undeformed cartridge height 1102a. Referring now to FIG. 84D, the anvil 1140 can be moved into a final, fired position in which the staples 1120 have been fully formed, or at least formed to a desired height. In such a position, the tissue-contacting surface 1141 of anvil 1140 can be a distance 1101d away from the cartridge support surface 1131, wherein the distance 1101d can be shorter than the original, undeformed cartridge height 1102a. As also illustrated in FIG. 84D, the staple cavities 1115 may be fully, or at least substantially, collapsed and the staples 1120 may be completely, or at least substantially, surrounded by the collapsed second layer 1112. In various circumstances, the anvil 1140 can be thereafter moved away from the staple cartridge 1100. Once the anvil 1140 has been disengaged from the staple cartridge 1100, the cartridge body 1110 can at least partially re-expand in various locations, i.e., locations intermediate adjacent staples 1120, for example. In at least one embodiment, the crushed cartridge body 1110 may not resiliently re-expand. In various embodiments, the formed staples 1120 and, in addition, the cartridge body 1110 positioned intermediate adjacent staples 1120 may apply pressure, or compressive forces, to the tissue T which may provide various therapeutic benefits.

As discussed above, referring again to the embodiment illustrated in FIG. 84A, each staple 1120 can comprise staple legs 1121 extending therefrom. Although staples 1120 are depicted as comprising two staple legs 1121, various staples can be utilized which can comprise one staple leg or, alternatively, more than two staple legs, such as three staple legs or four staple legs, for example. As illustrated in FIG. 84A, each staple leg 1121 can be embedded in the second layer 1112 of the cartridge body 1110 such that the staples 1120 are secured within the second layer 1112. In various embodiments, the staples 1120 can be inserted into the staple cavities 1115 in cartridge body 1110 such that the tips 1123 of the staple legs 1121 enter into the cavities 1115 before the bases 1122. After the tips 1123 have been inserted into the cavities 1115, in various embodiments, the tips 1123 can be pressed into the

cover portions 1116 and incise the second layer 1112. In various embodiments, the staples 1120 can be seated to a sufficient depth within the second layer 1112 such that the staples 1120 do not move, or at least substantially move, relative to the second layer 1112. In certain embodiments, the staples 1120 can be seated to a sufficient depth within the second layer 1112 such that the bases 1122 are positioned or embedded within the staple cavities 1115. In various other embodiments, the bases 1122 may not be positioned or embedded within the second layer 1112. In certain embodiments, referring again to FIG. 84A, the bases 1122 may extend below the bottom surface 1118 of the cartridge body 1110. In certain embodiments, the bases 1122 can rest on, or can be directly positioned against, the cartridge support surface 1130. In various embodiments, the cartridge support surface 1130 can comprise support features extending therefrom and/or defined therein wherein, in at least one such embodiment, the bases 1122 of the staples 1120 may be positioned within and supported by one or more support grooves, slots, or troughs, 1132, for example, in the staple cartridge support 1130, as described in greater detail further below.

Further to the above, referring now to FIG. 85, the bases 1122 of the staples 1120 can be positioned directly against the support surface 1131 of staple cartridge support 1130. In various embodiments, including embodiments where the staple bases 1122 comprise circular or arcuate bottom surfaces 1124, for example, the staple bases 1122 may move or slide along the staple cartridge support surface 1131. Such sliding can occur when the anvil 1140 is pressed against the tips 1123 of the staple legs 1121 during the staple forming process. In certain embodiments, as described above and referring now to FIG. 86, the staple cartridge support 1130 can comprise one or more support slots 1132 therein which can be configured to eliminate, or at least reduce, the relative movement between the staple bases 1122 and the cartridge support surface 1131. In at least one such embodiment, each support slot 1132 can be defined by a surface contour which matches, or at least substantially matches, the contour of the bottom surface of the staple positioned therein. For example, the bottom surface 1124 of the base 1122 depicted in FIG. 86 can comprise a circular, or at least substantially circular, surface and the support slot 1132 can also comprise a circular, or at least substantially circular, surface. In at least one such embodiment, the surface defining the slot 1132 can be defined by a radius of curvature which is greater than or equal to a radius of curvature which defines bottom surface 1124. Although the slots 1132 may assist in preventing or reducing relative sliding movement between the staples 1120 and the staple cartridge support 1130, the slots 1132 may also be configured to prevent or reduce relative rotational movement between the staples 1120 and the staple cartridge support 1130. More particularly, in at least one embodiment, the slots 1132 can be configured to closely receive the bases 1122 in order to prevent or reduce the rotation of the staples 1120 about axes 1129, for example, such that the staples 1120 do not rotate or twist when they are being deformed.

In various embodiments, further to the above, each staple 1120 can be formed from a round, or an at least substantially round, wire. In certain embodiments, the legs and the base of each staple can be formed from a wire having a non-circular cross-section, such as a rectangular cross-section, for example. In at least one such embodiment, the staple cartridge support 1130 can comprise corresponding non-circular slots, such as rectangular slots, for example, configured to receive the bases of such staples. In various embodiments, referring now to FIG. 87, each staple 1120 can comprise a crown, such

as a crown 1125, for example, overmolded onto a base 1122 wherein each crown 1125 can be positioned within a support slot in the staple cartridge support 1130. In at least one such embodiment, each crown 1125 can comprise a square and/or rectangular cross-section, for example, which can be configured to be received within square and/or rectangular slots 1134, for example, in the staple cartridge support 1130. In various embodiments, the crowns 1125 can be comprised of a bioabsorbable plastic, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example, and can be formed around the bases 1122 of the staples 1120 by an injection molding process, for example. Various crowns and methods for forming various crowns are disclosed in U.S. patent application Ser. No. 11/541,123, entitled SURGICAL STAPLES HAVING COMPRESSIBLE OR CRUSHABLE MEMBERS FOR SECURING TISSUE THEREIN AND STAPLING INSTRUMENTS FOR DEPLOYING THE SAME, filed on Sep. 29, 2006, the entire disclosure of which is incorporated by reference herein. Referring again to FIG. 87, the slots 1134 can further comprise lead-ins, or bevels, 1135 which can be configured to facilitate the insertion of the crowns 1125 into the slots 1134. In various embodiments, the bases and/or crowns of the staples 1120 may be positioned within the slots 1134 when the staple cartridge 1100 is assembled to the staple cartridge support 1130. In certain embodiments, the crowns 1125 of the staples 1120 may be aligned with the slots 1134 when the staple cartridge 1100 is assembled to the staple cartridge support 1130. In at least one such embodiment, the crowns 1125 may not enter into the slots 1134 until a compressive force is applied to the staple legs 1121 and the bases and/or crowns of the staples 1120 are pushed downwardly into the slots 1134.

In various embodiments, referring now to FIGS. 88 and 89, a staple cartridge, such as staple cartridge 1200, for example, can comprise a compressible, implantable cartridge body 1210 comprising an outer layer 1211 and an inner layer 1212. Similar to the above, the staple cartridge 1200 can comprise a plurality of staples 1220 positioned within the cartridge body 1210. In various embodiments, each staple 1220 can comprise a base 1222 and one or more staple legs 1221 extending therefrom. In at least one such embodiment, the staple legs 1221 can be inserted into the inner layer 1212 and seated to a depth in which the bases 1222 of the staples 1220 abut and/or are positioned adjacent to the bottom surface 1218 of the inner layer 1212, for example. In the embodiment depicted in FIGS. 88 and 89, the inner layer 1212 does not comprise staple cavities configured to receive a portion of the staples 1220 while, in other embodiments, the inner layer 1212 can comprise such staple cavities. In various embodiments, further to the above, the inner layer 1212 can be comprised of a compressible material, such as bioabsorbable foam and/or oxidized regenerated cellulose (ORC), for example, which can be configured to allow the cartridge body 1210 to collapse when a compressive load is applied thereto. In various embodiments, the inner layer 1212 can be comprised of a lyophilized foam comprising polylactic acid (PLA) and/or polyglycolic acid (PGA), for example. The ORC may be commercially available under the trade name Surgicel and can comprise a loose woven fabric (like a surgical sponge), loose fibers (like a cotton ball), and/or a foam. In at least one embodiment, the inner layer 1212 can be comprised of a material including medicaments, such as freeze-dried throm-

bin and/or fibrin, for example, contained therein and/or coated thereon which can be water-activated and/or activated by fluids within the patient's body, for example. In at least one such embodiment, the freeze-dried thrombin and/or fibrin can be held on a Vicryl (PGA) matrix, for example. In certain circumstances, however, the activatable medicaments can be unintentionally activated when the staple cartridge 1200 is inserted into a surgical site within the patient, for example. In various embodiments, referring again to FIGS. 88 and 89, the outer layer 1211 can be comprised of a water impermeable, or at least substantially water impermeable, material such that liquids do not come into contact with, or at least substantially contact, the inner layer 1212 until after the cartridge body 1210 has been compressed and the staple legs have penetrated the outer layer 1211 and/or after the outer layer 1211 has been incised in some fashion. In various embodiments, the outer layer 1211 can be comprised of a buttress material and/or plastic material, such as polydioxanone (PDS) and/or polylglycolic acid (PGA), for example. In certain embodiments, the outer layer 1211 can comprise a wrap which surrounds the inner layer 1212 and the staples 1220. More particularly, in at least one embodiment, the staples 1220 can be inserted into the inner layer 1212 and the outer layer 1211 can be wrapped around the sub-assembly comprising the inner layer 1212 and the staples 1220 and then sealed.

In various embodiments, referring now to FIGS. 90 and 91, a staple cartridge, such as staple cartridge 1300, for example, can comprise a compressible, implantable cartridge body 1310 including an outer layer 1311 and an inner layer 1312. Similar to the above, the staple cartridge 1300 can further comprise staples 1320 positioned within the cartridge body 1310 wherein each staple 1320 can comprise a base 1322 and one or more legs 1321 extending therefrom. Similar to staple cartridge 1200, the bases 1322 of staples 1320 can extend below the bottom surface 1318 of the inner layer 1312 and the outer layer 1311 can surround the bases 1322. In at least one such embodiment, the outer layer 1311 can be sufficiently flexible so as to envelop each staple base 1322 such that the outer layer 1311 conforms to the contour of the bases 1322. In at least one alternative embodiment, referring again to FIG. 89, the outer layer 1211 can be sufficiently rigid such that it extends around the bases 1222 without conforming to each base 1222. In any event, in various embodiments, the outer layer 1311 can be positioned intermediate the bases 1322 of staples 1320 and a staple cartridge support surface, such as support surfaces 1031 or 1131, for example, supporting the staple cartridge 1300. In at least one such embodiment, the outer layer 1311 can be positioned intermediate the bases 1322 and support slots, such as slots 1032 or 1132, for example, defined in the staple cartridge support surface. In at least one such embodiment, further to the above, the outer layer 1311 can be configured to limit the movement of the bases 1322 and/or increase the coefficient of friction between the bases 1322 and the staple cartridge support surface and/or support slots in order to reduce relative movement therebetween. In various alternative embodiments, referring now to FIGS. 92 and 93, the outer layer of a staple cartridge, such as staple cartridge 1400, for example, may not entirely surround the staples positioned therein. In at least one such embodiment, an outer layer 1411 of a compressible, implantable cartridge body 1410 may be assembled to the inner layer 1412 before the staple legs 1421 of staples 1420 are inserted into the cartridge body 1410. As a result of the above, the bases 1422 of staples 1420 may extend outside of the outer layer 1411 and, in at least one such embodiment, the bases 1422 may be positioned directly into the support slots 1032 or 1132 within the staple cartridge support surfaces 1031 or 1131, for

example. In various embodiments, the staple legs 1421 may incise the outer layer 1411 when they are inserted there-through. In various circumstances, the holes created by the staple legs 1421 may closely surround the staple legs 1421 such that very little, if any, fluid can leak between the staple legs 1421 and the outer layer 1411 which can reduce the possibility of, or prevent, the medicament contained within the staple cartridge body 1410 from being activated and/or leaking out of the cartridge body 1410 prematurely.

As discussed above, referring again to FIGS. 88 and 89, the legs 1221 of the staples 1220 can be embedded within the cartridge body 1210 and the bases 1222 of staples 1220 may extend outwardly from the bottom surface 1218 of the inner layer 1212. In various embodiments, further to the above, the inner layer 1212 may not comprise staple cavities configured to receive the staples 1220. In various other embodiments, referring now to FIGS. 94 and 95, a staple cartridge, such as staple cartridge 1500, for example, may comprise a compressible, implantable cartridge body 1510 comprising staple cavities 1515 which can be configured to receive at least a portion of the staples 1520 therein. In at least one such embodiment, a top portion of the staple legs 1521 of the staples 1520 may be embedded in the inner layer 1512 while a bottom portion of the staple legs 1521, and the bases 1522, may be positioned within the staple cavities 1515. In certain embodiments, the bases 1522 may be entirely positioned in the staple cavities 1515 while, in some embodiments, the bases 1522 may at least partially extend below the bottom surface 1518 of the inner layer 1512. Similar to the above, the outer layer 1511 may enclose the inner layer 1512 and the staples 1520 positioned therein. In certain other embodiments, referring now to FIG. 96, a staple cartridge 1600 may comprise staples 1620 positioned within staple cavities 1615 in a compressible, implantable cartridge body 1610 wherein at least a portion of the staples 1620 are not enclosed by the outer layer 1611. In at least one such embodiment, each staple 1620 can comprise staple legs 1621 which are at least partially embedded in the inner layer 1612 and, in addition, bases 1622 which extend outwardly around the outer layer 1611.

In various embodiments, referring now to FIGS. 97 and 98, a staple cartridge, such as staple cartridge 1700, for example, can comprise a compressible, implantable cartridge body 1710 and a plurality of staples 1720 at least partially positioned within the cartridge body 1710. The cartridge body 1710 can comprise an outer layer 1711, an inner layer 1712, and, in addition, an alignment matrix 1740 which can be configured to align and/or retain the staples 1720 in position within the cartridge body 1710. In at least one embodiment, the inner layer 1712 can comprise a recess 1741 which can be configured to receive the alignment matrix 1740 therein. In various embodiments, the alignment matrix 1740 can be press-fit within the recess 1741 and/or otherwise suitably secured to the inner layer 1712 utilizing at least one adhesive, such as fibrin and/or protein hydrogel, for example. In at least one embodiment, the recess 1741 can be configured such that the bottom surface 1742 of alignment matrix 1740 is aligned, or at least substantially aligned, with the bottom surface 1718 of the inner layer 1712. In certain embodiments, the bottom surface 1742 of the alignment matrix can be recessed with respect to and/or extend from the bottom surface 1718 of the second layer 1712. In various embodiments, each staple 1720 can comprise a base 1722 and one or more legs 1721 extending from the base 1722, wherein at least a portion of the staple legs 1721 can extend through the alignment matrix 1740. The alignment matrix 1740 can further comprise a plurality of apertures and/or slots, for example, extending therethrough which can be configured to receive the staple legs 1721

61

therein. In at least one such embodiment, each aperture can be configured to closely receive a staple leg **1721** such that there is little, if any, relative movement between the staple leg **1721** and the sidewalls of the aperture. In certain embodiments, the alignment matrix apertures may not extend entirely through the alignment matrix **1740** and the staple legs **1721** may be required to incise the alignment matrix **1740** as the staple legs **1721** are pushed therethrough.

In various embodiments, the alignment matrix **1740** can be comprised of a molded plastic body which, in at least one embodiment, can be stiffer or less compressible than the inner layer **1712** and/or the outer layer **1711**. In at least one such embodiment, the alignment matrix **1740** can be comprised of a plastic material and/or any other suitable material, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example. In certain embodiments, the alignment matrix **1740** can be assembled to the inner layer **1712** and the staple legs **1721** can thereafter be inserted through the alignment matrix **1740** and embedded into the inner layer **1712**. In various embodiments, the bottom surface **1742** of the alignment matrix **1740** can comprise one or more grooves, slots, or troughs, for example, which can be configured to at least partially receive the bases **1722** of the staples **1720**. Similar to the above, the outer layer **1711** can then be placed around the subassembly comprising the inner layer **1712**, the alignment matrix **1740**, and the staples **1720**. Alternatively, the outer layer **1711** can be placed around a subassembly comprising the inner layer **1712** and the alignment matrix **1740** wherein the staples **1720** can be thereafter inserted through the outer layer **1711**, the alignment matrix **1740**, and the inner layer **1712**. In any event, as a result of the above, the inner layer **1712**, the alignment matrix **1740**, and/or the outer layer **1711** can be configured to retain the staples **1720** in position until and/or after they are deformed by an anvil as described above. In at least one such embodiment, the alignment matrix **1740** can serve to hold the staples **1720** in place before the staple cartridge **1700** is implanted within a patient and, in addition, secure the tissue along the staple line after the staple cartridge **1700** has been implanted. In at least one embodiment, the staples **1720** may be secured within the alignment matrix **1740** without being embedded in the inner layer **1712** and/or the outer layer **1711**, for example.

In various embodiments, referring now to FIGS. **99-105**, a staple cartridge, such as staple cartridge **1800**, for example, can be assembled by compressing an inner layer **1812**, inserting staples, such as staples **1820**, for example, into the inner layer **1812**, and wrapping the inner layer **1812** with an outer layer **1811**. Referring primarily to FIG. **99**, a compressible inner layer **1812** is illustrated as comprising a plurality of staple cavities **1815** defined therein, although other embodiments are envisioned in which the inner layer **1812** does not comprise staple cavities, as described above. Referring now to FIG. **100**, the compressible inner layer **1812** can be positioned intermediate a transfer plate **1850** and a support plate **1860** and compressed between the compression surfaces **1852** and **1862** thereof, respectively. As illustrated in FIG. **100**, the top and bottom surfaces of the inner layer **1812** can be compressed toward one another and, in response thereto, the inner layer **1812** can bulge outwardly in the lateral directions. In certain embodiments, the inner layer **1812** can be compressed to a height which is approximately one-third of its original height, for example, and can have a height or thickness between approximately 0.06" and approximately 0.08" in its compressed state, for example. As also illustrated in FIG. **100**, the transfer plate **1850** can further comprise a plurality of staples, such as staples **1820**, for example, positioned within a plurality of staple wells **1853**. In addition, the

62

transfer plate **1850** can further comprise a plurality of drivers **1851** which can be configured to push the staples **1820** upwardly and out of the staple wells **1853**. Referring now to FIG. **101**, the drivers **1851** can be utilized to push the staple legs **1821** of the staples **1820** into and through the compressed inner layer **1812**. In various embodiments, the drivers **1851** can be configured such that the top surfaces thereof are positioned flush, or at least nearly flush, with the compression surface **1852** of the transfer plate **1850** when the staples **1820** have been fully deployed from the staple wells **1853** of transfer plate **1850**. In certain embodiments, as also illustrated in FIG. **101**, the support plate **1860** can comprise a plurality of receiving apertures **1861** which can be configured to receive the staple legs **1821**, or at least the tips of the staple legs **1821**, after they are pushed through the inner layer **1812**. The receiving apertures **1861**, or the like, may be necessitated in embodiments where the inner layer **1812** has been compressed to a height which is shorter than the height of the staples **1820** and, thus, when the staples **1820** have been fully ejected from the staple wells **1853**, the staple legs **1821** may protrude from the top surface of the compressed inner layer **1812**. In certain other embodiments, the inner layer **1812** may be compressed to a height which is taller than the height of the staples **1820** and, as a result, the receiving apertures **1861** in support plate **1860** may be unnecessary.

After the staples **1820** have been inserted into the inner layer **1812**, referring now to FIG. **102**, the support plate **1860** can be moved away from the transfer plate **1850** in order to allow the inner layer **1812** to decompress. In such circumstances, the inner layer **1812** can resiliently re-expand to its original, or at least near-original, uncompressed height. As the inner layer **1812** re-expands, the height of the inner layer **1812** can increase such that it exceeds the height of the staples **1820** and such that the staple legs **1821** of the staples **1820** no longer protrude from the top surface of the inner layer **1812**. In various circumstances, the receiving apertures **1861** can be configured to hold the staple legs **1821** in position at least until the support plate **1860** has been sufficiently moved away such that the legs **1821** are no longer positioned within the receiving apertures **1861**. In such circumstances, the receiving apertures **1861** can assist in maintaining the relative alignment of the staples **1820** within the inner layer **1812** as it re-expands. In various circumstances, the inner layer **1812** and the staples **1820** positioned therein can comprise a subassembly **1801** which, referring now to FIG. **103**, can be inserted into an outer layer **1811**, for example. In at least one such embodiment, the outer layer **1811** can comprise a cavity **1802** defined therein which can be configured to receive the subassembly **1801** therein. In various circumstances, a tool, such as pliers **1855**, for example, can be utilized to pull the outer layer **1811** onto the subassembly **1801**. Once the subassembly **1801** has been sufficiently positioned within the outer layer **1811**, referring now to FIG. **104**, the outer layer **1811** can be sealed. In various embodiments, the outer layer **1811** can be sealed utilizing the application of heat energy to a portion thereof. More particularly, in at least one embodiment, the outer layer **1811** can be comprised of a plastic material wherein the open end of the outer layer **1811** can be heat-staked by one or more heated elements, or irons, **1856** in order to bond and/or seal the perimeter of the open end of the outer layer **1811** together. In at least one such embodiment, referring now to FIG. **105**, an excess portion **1857** of the outer layer **1811** can be removed and the staple cartridge **1800** can then be used as described herein.

As described above, a staple cartridge can be positioned within and/or secured to a staple cartridge attachment portion. In various embodiments, referring now to FIGS. **106** and **107**,

63

a staple cartridge attachment portion can comprise a staple cartridge channel, such as staple cartridge channel 1930, for example, which can be configured to receive at least a portion of a staple cartridge, such as staple cartridge 1900, for example, therein. In at least one embodiment, the staple cartridge channel 1930 can comprise a bottom support surface 1931, a first lateral support wall 1940, and a second lateral support wall 1941. In use, the staple cartridge 1900 can be positioned within the staple cartridge channel 1930 such that the staple cartridge 1900 is positioned against and/or adjacent to the bottom support surface 1931 and positioned intermediate the first lateral support wall 1940 and the second lateral support wall 1941. In certain embodiments, the first lateral support wall 1940 and the second lateral support wall 1941 can define a lateral gap therebetween. In at least one such embodiment, the staple cartridge 1900 can comprise a lateral width 1903 which is the same as and/or wider than the lateral gap defined between the support walls 1940 and 1941 such that a compressible, implantable cartridge body 1910 of the staple cartridge 1900 can fit securely between the walls 1940 and 1941. In certain other embodiments, the lateral width 1903 of the staple cartridge 1900 can be shorter than the gap defined between the first and second side walls 1940 and 1941. In various embodiments, at least a portion of the walls 1940 and 1941 and the bottom support surface 1931 can be defined by a stamped metal channel while, in at least one embodiment, at least a portion of the lateral support wall 1940 and/or lateral support wall 1941 can be comprised of a flexible material, such as an elastomeric material, for example. Referring primarily to FIG. 106, the first side wall 1940 and the second side wall 1941 of the staple cartridge channel 1930 can each be comprised of a rigid portion 1933 extending upwardly from the bottom support surface 1931 and a flexible portion 1934 extending upwardly from the rigid portions 1933.

In various embodiments, further to the above, the cartridge body 1910 of staple cartridge 1900 can be comprised of one or more compressible layers, such as first layer 1911 and second layer 1912, for example. When the cartridge body 1910 is compressed against the bottom support surface 1931 by an anvil, as described above, the side portions of the cartridge body 1910 can expand laterally. In embodiments where the staple cartridge 1930 is comprised of rigid side walls, the lateral expansion of the cartridge body 1910 can be prevented, or at least limited, by the rigid side walls and, as a result, a significant amount of internal pressure, or stress, can be developed within the cartridge body 1910. In embodiments where at least a portion of the staple cartridge 1930 is comprised of flexible side walls, the flexible side walls can be configured to flex laterally and permit the side portions of the cartridge body 1910 to expand laterally, thereby reducing the internal pressure, or stress, generated within the cartridge body 1910. In embodiments where the cartridge channel does not comprise lateral side walls, or comprises lateral sidewalls which are relatively shorter than the staple cartridge, the side portions of the staple cartridge may expand laterally uninhibited, or at least substantially uninhibited. In any event, referring now to FIG. 107, a staple cartridge channel 2030 can comprise lateral sidewalls 2040 and 2041 which can be entirely comprised of a flexible material, such as an elastomeric material, for example. The staple cartridge channel 2030 can further comprise lateral slots 2033 extending along the sides of the bottom support surface 2031 of the staple cartridge channel 2030 which can be configured to receive and secure at least a portion of the lateral sidewalls 2040 and 2041 therein. In certain embodiments, the lateral side walls 2040 and 2041 can be secured in the slots 2033 via a snap-fit

64

and/or press-fit arrangement while, in at least some embodiments, the lateral side walls 2040 and 2041 can be secured in the slots 2033 by one or more adhesives. In at least one embodiment, the sidewalls 2040 and 2041 may be detachable from the bottom support surface 2031 during use. In any event, a compressible, implantable cartridge body 2010 can be detached and/or disengaged from the lateral side walls 2040 and 2041 when the cartridge body 2010 is implanted with the staples 2020.

In various embodiments, referring now to FIG. 108, a surgical instrument can comprise a shaft 2150 and an end effector extending from the distal end of the shaft 2150. The end effector can comprise, similar to the above, a staple cartridge channel 2130, an anvil 2140 movable between an open position and a closed position, and a staple cartridge 2100 positioned intermediate the staple cartridge channel 2130 and the anvil 2140. Also similar to the above, the staple cartridge 2100 can comprise a compressible, implantable cartridge body 2110 and a plurality of staples 2120 positioned in the cartridge body 2110. In various embodiments, the staple cartridge channel 2130 can comprise, one, a bottom support surface 2131 against which the staple cartridge 2100 can be positioned, two, a distal end 2135 and, three, a proximal end 2136. In at least one embodiment, as illustrated in FIG. 108, the staple cartridge 2100 can comprise a first end 2105 which can be positionable in the distal end 2135 of the staple cartridge channel 2130 and a second end 2106 which can be positionable in the proximal end 2136 of the staple cartridge channel 2130. In various embodiments, the distal end 2135 of the staple cartridge channel 2130 can comprise at least one distal retention feature, such as a retention wall 2137, for example, and, similarly, the proximal end 2136 can comprise at least one proximal retention feature, such as a retention wall 2138, for example. In at least one such embodiment, the distal retention wall 2137 and the proximal retention wall 2138 can define a gap therebetween which can be equal to or less than the length of the staple cartridge 2100 such that the staple cartridge 2100 can fit securely within the staple cartridge channel 2130 when the staple cartridge 2100 is inserted therein.

In various embodiments, referring again to FIGS. 88 and 89, a staple cartridge, such as staple cartridge 1200, for example, can comprise a flat, or at least substantially flat, tissue-contacting surface 1219. In at least one such embodiment, the staple cartridge body 1210 of staple cartridge 1200 can comprise a first end 1205 which can be defined by a first height, or thickness, 1207 and a second end 1206 which can be defined by a second height, or thickness, 1208, wherein the first height 1207 can be equal to, or at least substantially equal to, the second height 1208. In certain embodiments, the cartridge body 1210 can comprise a constant, or at least substantially constant, height, or thickness, between the first end 1205 and the second end 1206. In at least one such embodiment, the tissue-contacting surface 1219 can be parallel, or at least substantially parallel, to the bottom surface 1218 of the cartridge body 1210. In various embodiments, referring once again to FIG. 108, the first end 2105 of the cartridge body 2110 of staple cartridge 2100 can be defined by a first height 2107 which is different than a second height 2108 of the second end 2106. In the illustrated embodiment, the first height 2107 is larger than the second height 2108, although the second height 2108 could be larger than the first height 2107 in alternative embodiments. In various embodiments, the height of the cartridge body 2110 can decrease linearly and/or geometrically between the first end 2105 and the second end 2106. In at least one such embodiment, the tissue-contacting surface 2119, which extends between the first end

65

2105 and the second end 2106, can be oriented along an angle defined therebetween. In at least one such embodiment, the tissue-contacting surface 2119 may not be parallel to the bottom surface 2118 of the cartridge body 2110 and/or parallel to the support surface 2131 of the staple cartridge channel 2130.

In various embodiments, referring again to FIGS. 108 and 109, the anvil 2140 can comprise a tissue-contacting surface 2141 which can be parallel, or at least substantially parallel, to the support surface 2131 of the staple cartridge channel 2130 when the anvil 2140 is in a closed position, as illustrated in FIG. 109. When the anvil 2140 is in a closed position, the anvil 2140 can be configured to compress the first end 2105 of the staple cartridge 2100 more than the second end 2106 owing to the taller height of the first end 2105 and the shorter height of the second end 2106. In some circumstances, including circumstances where the tissue T positioned intermediate the tissue contacting surfaces 2119 and 2141 has a constant, or at least substantially constant, thickness, the pressure generated within the tissue T and the cartridge 2100 can be greater at the distal end of the end effector than the proximal end of the end effector. More particularly, when the tissue T between the anvil 2140 and the staple cartridge 2100 has a substantially constant thickness, the tissue T positioned intermediate the distal end 2145 of the anvil 2140 and the first end 2105 of the staple cartridge 2100 can be more compressed than the tissue T positioned intermediate the proximal end 2146 of the anvil 2140 and the second end 2106 of the staple cartridge 2100. In various embodiments, a pressure gradient can be generated within the tissue T between the proximal end and the distal end of the end effector. More particularly, in at least one embodiment, when the tissue T between the anvil 2140 and the staple cartridge 2100 has a substantially constant thickness and the height of the staple cartridge 2100 decreases linearly from the distal end to the proximal end of the end effector, the pressure within the tissue T can decrease linearly from the distal end of the end effector to the proximal end of the end effector. Similarly, in at least one embodiment, when the tissue T between the anvil 2140 and the staple cartridge 2100 has a substantially constant thickness and the height of the staple cartridge 2100 decreases geometrically from the distal end to the proximal end of the end effector, the pressure within the tissue T can decrease geometrically from the distal end of the end effector to the proximal end of the end effector.

In various embodiments, referring again to FIG. 108, the tissue T positioned intermediate the staple cartridge 2100 and the anvil 2140 may not have a constant thickness throughout. In at least one such circumstance, the tissue T positioned between the proximal end 2146 of the anvil 2140 and the second end 2106 of the staple cartridge 2100 may be thicker than the tissue T positioned between the distal end 2145 of the anvil 2140 and the first end 2105 of the staple cartridge 2100. In such circumstances, as a result, the thicker tissue T may be generally positioned above the shorter proximal end 2106 of the staple cartridge 2100 and the thinner tissue T may be generally positioned above the taller distal end 2105. In use, the firing collar 2152 of the shaft 2150 can be advanced distally along the shaft spine 2151 such that the firing collar 2152 engages the cam portion 2143 of the anvil 2140 and rotates the anvil 2140 toward the staple cartridge 2100 as illustrated in FIG. 109. Once the anvil 2140 has been rotated into a fully-closed position, the tissue T may be compressed between the tissue-contacting surfaces 2119 and 2141 and, even though the height of the staple cartridge 2100 may not be constant between the proximal and distal ends of the end effector, the pressure or compressive forces applied to the

66

tissue T may be constant, or at least substantially constant, thereacross. More particularly, as the thinner tissue T may be associated with the taller height of the staple cartridge 2100 and the thicker tissue T may be associated with the shorter height of the staple cartridge 2100, the cumulative, or summed, height of the tissue T and the staple cartridge 2100 may be constant, or at least substantially constant, between the proximal and distal ends of the end effector and, as a result, the compression of this cumulative height by the anvil 2140 may be constant, or at least substantially constant, thereacross.

In various embodiments, referring again to FIGS. 108 and 109, the staple cartridge 2100 can comprise an asymmetrical configuration. In at least one such embodiment, for example, the height of the staple cartridge 2100 at the first end 2105 thereof may be higher than the height of the staple cartridge 2100 at the second end 2106 thereof. In certain embodiments, the staple cartridge 2100 and/or the staple cartridge channel 2130 can comprise one or more alignment and/or retention features which can be configured to assure that the staple cartridge 2100 can only be positioned within the staple cartridge channel 2130 in one orientation, i.e., an orientation in which the first end 2105 is positioned in the distal end 2135 of the staple cartridge channel 2130 and the second end 2106 is positioned in the proximal end 2136. In various alternative embodiments, the staple cartridge 2100 and/or the staple cartridge channel 2130 can comprise one or more alignment and/or retention features which can be configured to permit the staple cartridge 2100 to be positioned within the staple cartridge channel 2130 in more than one orientation. Referring now to FIG. 110, for example, the staple cartridge 2100 can be positioned within the staple cartridge channel 2130 such that the first end 2105 of the staple cartridge 2100 can be positioned in the proximal end 2136 of the staple cartridge channel 2130 and the second end 2106 can be positioned in the distal end 2135. In various embodiments, as a result, the shorter height of the staple cartridge 2100 can be positioned proximate the distal retention wall 2137 and the taller height of the staple cartridge 2100 can be positioned proximate to the proximal retention wall 2138. In at least one such embodiment, the staple cartridge 2100 can be suitably arranged to apply a constant, or at least substantially constant, clamping pressure to tissue T having a thicker portion within the distal end of the end effector and a thinner portion within the proximal end of the end effector. In various embodiments, the staple cartridge 2100, for example, can be selectively oriented within the staple cartridge channel 2130. In at least one such embodiment, the alignment and/or retention features of the staple cartridge 2100 can be symmetrical and a surgeon can selectively orient the staple cartridge 2100 within the staple cartridge channel 2130 in the orientations depicted in FIG. 108 and FIG. 110, for example.

Further to the above, the implantable cartridge body 2110 can comprise a longitudinal axis 2109 which, when the staple cartridge 2100 is positioned in the staple cartridge channel 2130, can extend between the proximal and distal ends of the end effector. In various embodiments, the thickness of the cartridge body 2110 can generally decrease and/or generally increase between the first end 2105 and the second end 2106 along the longitudinal axis 2109. In at least one such embodiment, the distance, or height, between the bottom surface 2118 and the tissue-contacting surface 2119 can generally decrease and/or generally increase between the first end 2105 and the second end 2106. In certain embodiments, the thickness of the cartridge body 2110 can both increase and decrease along the longitudinal axis 2109. In at least one such embodiment, the thickness of the cartridge body 2110 can

67

comprise one or more portions which increase in thickness and one or more portions which can decrease in thickness. In various embodiments, referring again to FIG. Z, the staple cartridge **2100** can comprise a plurality of staples **2120** positioned therein. In use, as described above, the staples **2120** can be deformed when the anvil **2140** is moved into a closed position. In certain embodiments, each staple **2120** can have the same, or at least substantially the same, height. In at least one such embodiment, the height of a staple can be measured from the bottom of the base of the staple to the top, or tip, of the tallest leg of the staple, for example.

In various embodiments, the staples within a staple cartridge can have different staple heights. In at least one such embodiment, a staple cartridge can comprise a first group of staples having a first staple height which are positioned in a first portion of a compressible cartridge body and a second group of staples having a second staple height which are positioned in a second portion of the compressible cartridge body. In at least one embodiment, the first staple height can be taller than the second staple height and the first group of staples can be positioned in the first end **2105** of the staple cartridge **2100** while the second group of staples can be positioned in the second end **2106**. Alternatively, the taller first group of staples can be positioned in the second end **2106** of the staple cartridge **2100** while the shorter second group of staples can be positioned in the first end **2105**. In certain embodiments, a plurality of staple groups, each group having a different staple height, can be utilized. In at least one such embodiment, a third group having an intermediate staple height can be positioned in the cartridge body **2110** intermediate the first group of staples and the second group of staples. In various embodiments, each staple within a staple row in the staple cartridge can comprise a different staple height. In at least one embodiment, the tallest staple within a staple row can be positioned on a first end of a staple row and the shortest staple can be positioned on an opposite end of the staple row. In at least one such embodiment, the staples positioned intermediate the tallest staple and the shortest staple can be arranged such that the staple heights descend between the tallest staple and the shortest staple, for example.

In various embodiments, referring now to FIG. **111**, an end effector of a surgical stapler can comprise an anvil **2240**, a staple cartridge channel **2230**, and a staple cartridge **2200** supported by the staple cartridge channel **2230**. The staple cartridge **2200** can comprise a compressible, implantable cartridge body **2210** and a plurality of staples, such as staples **2220a** and staples **2220b**, for example, positioned therein. In various embodiments, the staple cartridge channel **2230** can comprise a cartridge support surface **2231** and a plurality of staple support slots, such as support slots **2232a** and **2232b**, for example, defined therein. In at least one such embodiment, the staple cartridge **2200** can comprise two outer rows of staples **2220a** and two inner rows of staples **2220b**, wherein the support slots **2232a** can be configured to support the staples **2220a** and the support slots **2232b** can be configured to support the staples **2220b**. Referring to FIGS. **111** and **112**, the anvil **2240** can comprise a plurality of staple forming pockets **2242** defined therein which can be configured to receive and deform the staples **2220a** and **2220b** when the anvil **2240** is moved toward the staple cartridge **2200**. In at least one such embodiment, the bottom surfaces of the support slots **2232a** can be a first distance **2201a** away from the top surfaces of the staple forming pockets **2242** while the bottom surfaces of the support slots **2232b** can be a second distance **2201b** away from the top surfaces of the staple forming pockets **2242**. In at least one such embodiment, the support slots **2232b** are positioned closer to the anvil **2240**

68

owing to the raised step in the support surface **2231** in which they are defined. Owing to the different distances **2201a** and **2201b**, in various embodiments, the outer rows of staples **2220a** and the inner rows of staples **2220b** can be deformed to different formed heights. In various circumstances, staples deformed to different formed heights can apply different clamping pressures or forces to the tissue **T** being stapled. In addition to the above, the staples can begin with different unformed staple heights. In at least one such embodiment, referring again to FIG. **111**, the outer staples **2220a** can have an initial, unformed height which is greater than the initial, unformed height of the inner staples **2220b**. As illustrated in FIGS. **111** and **112**, the inner staples **2220b**, which have a shorter unformed height than the outer staples **2220a**, can also have a shorter formed height than the outer staples **2220b**. In various alternative embodiments, the inner staples **2220b** may have a taller unformed height than the outer staples **2220a** yet have a shorter deformed staple height than the outer staples **2220a**.

In various embodiments, further to the above, the anvil **2240** can be moved into a closed position, as illustrated in FIG. **112**, in order to compress the cartridge body **2210** and deform the staples **2220a** and **2220b**. In certain embodiments, a surgical stapler comprising the end effector depicted in FIGS. **111** and **112**, for example, can further comprise a cutting member which can be configured to transect the tissue **T** positioned intermediate the anvil **2240** and the staple cartridge **2200**. In at least one such embodiment, the anvil **2240**, the staple cartridge channel **2230** and/or the staple cartridge **2200** can define a slot configured to slidably receive a cutting member therein. More particularly, the anvil **2240** can comprise a slot portion **2249**, the staple cartridge channel **2230** can comprise a slot portion **2239**, and the staple cartridge **2200** can comprise a slot portion **2203** which can be aligned, or at least substantially aligned, with one another when the anvil **2240** is in a closed, or at least substantially closed, position. In various embodiments, the cutting member can be moved from the proximal end of the end effector toward the distal end of the end effector after the anvil **2240** has been closed and the staples **2220a**, **2220b** have been deformed. In at least one embodiment, the cutting member can be moved independently of the staple deformation process. In certain embodiments, the cutting member can be advanced at the same time that the staples are being deformed. In any event, in at least one embodiment, the cutting member can be configured to incise the tissue along a path positioned intermediate the inner rows of staples **2220b**.

In various embodiments, as illustrated in FIG. **112**, the inner staples **2220b** can be formed to a shorter height than the outer staples **2220a** wherein the inner staples **2220b** can apply a larger clamping pressure or force to the tissue adjacent to the cut line created by the cutting member. In at least one such embodiment, the larger clamping pressure or force created by the inner staples **2220b** can provide various therapeutic benefits such as reducing bleeding from the incised tissue **T** while the smaller clamping pressure created by the outer staples **2220a** can provide flexibility within the stapled tissue. In various embodiments, referring again to FIGS. **111** and **112**, the anvil **2240** can further comprise at least one piece of buttress material, such as buttress material **2260**, for example, attached thereto. In at least one such embodiment, the legs of the staples **2220a**, **2220b** can be configured to incise the buttress material **2260** and/or pass through apertures in the buttress material **2260** when the staple cartridge **2200** is compressed by the anvil **2240** and thereafter contact the staple forming pockets **2242** in the anvil **2240**. As the legs of the staples **2220a**, **2220b** are being deformed, the legs can contact

and/or incise the buttress material **2260** once again. In various embodiments, the buttress material **2260** can improve the hemostasis of and/or provide strength to the tissue being stapled.

In various embodiments, referring again to FIGS. **111** and **112**, the bottom surface of the cartridge body **2210** can comprise a stepped contour which matches, or at least substantially matches, the stepped contour of the cartridge support surface **2231**. In certain embodiments, the bottom surface of the cartridge body **2210** can deform to match, or at least substantially match, the contour of the cartridge support surface **2231**. In various embodiments, referring now to FIG. **113**, an end effector, similar to the end effector depicted in FIG. **111**, for example, can comprise a staple cartridge **2300** positioned therein. The staple cartridge **2300** can comprise a compressible, implantable body **2310** comprising an inner layer **2312** and an outer layer **2311** wherein, further to the above, the outer layer **2311** can be comprised of a water impermeable material in at least one embodiment. In various embodiments, the outer layer **2311** can extend around the staples **2220a**, **2220b** and can be positioned intermediate the staples **2220a**, **2220b** and the support slots **2232a**, **2232b**, respectively. In various embodiments, referring now to FIG. **114**, an end effector, similar to the end effector depicted in FIG. **111**, for example, can comprise a staple cartridge **2400** positioned therein. Similar to the staple cartridge **2300**, the compressible, implantable cartridge body **2410** of staple cartridge **2400** can comprise an inner layer **2412** and an outer layer **2411**; however, in at least one embodiment, the cartridge body **2410** may not comprise a cutting member slot therein. In at least one such embodiment, the cutting member may be required to incise the inner layer **2412** and/or the outer layer **2411**, for example, as it is advanced through the staple cartridge.

In various embodiments, referring now to FIG. **115**, an end effector of a surgical stapler can comprise an anvil **2540**, a staple cartridge channel **2530**, and a staple cartridge **2500** positioned in the staple cartridge channel **2530**. Similar to the above, the staple cartridge **2500** can comprise a compressible, implantable cartridge body **2510**, outer rows of staples **2220a**, and inner rows of staples **2220b**. The staple cartridge channel **2530** can comprise a flat, or an at least substantially flat, cartridge support surface **2531** and staple support slots **2532** defined therein. The anvil **2540** can comprise a stepped surface **2541** and a plurality of staple forming pockets, such as forming pockets **2542a** and **2542b**, for example, defined therein. Similar to the above, the forming pockets **2542a** and the support slots **2532** can define a distance therebetween which is greater than the distance between the forming pockets **2452b** and the support slots **2532**. In various embodiments, the anvil **2540** can further comprise a piece of buttress material **2560** attached to the stepped surface **2541** of the anvil **2540**. In at least one such embodiment, the buttress material **2560** can conform, or at least substantially conform, to the stepped surface **2541**. In various embodiments, the buttress material **2560** can be removably attached to the surface **2541** by at least one adhesive, such as fibrin and/or protein hydrogel, for example. In certain embodiments, the cartridge body **2510** can also comprise a stepped profile which, in at least one embodiment, parallels, or at least substantially parallels, the stepped surface **2541** of the anvil **2540**. More particularly, in at least one embodiment, the anvil **2540** can comprise steps **2548** extending toward the staple cartridge **2500** wherein the steps **2548** can comprise a step height which equals, or at least substantially equals, the step height of the steps **2508** extending from the cartridge body **2510**. In at least one such embodiment, as a result of the

above, the amount of the compressible cartridge body **2510** that can be captured in the first staples **2220a** can be different than the amount of the compressible cartridge body **2510** that can be captured in the second staples **2220b**, for example.

In various embodiments, referring now to FIG. **116**, an end effector can comprise an anvil **2640**, a staple cartridge channel **2530**, and a staple cartridge **2600** positioned therebetween. The staple cartridge **2600** can comprise a compressible, implantable cartridge body **2610** including an inner layer **2612**, an outer layer **2611**, and a plurality of staples, such as staples **2220a** and **2200b**, for example, positioned therein. In various embodiments, the anvil **2640** can comprise a plurality of staple forming pockets **2642** in surface **2641** and the staple cartridge channel **2530** can comprise a plurality of staple forming slots **2532** defined in the support surface **2531**. As illustrated in FIG. **116**, the anvil surface **2641** can be parallel, or at least substantially parallel, to the cartridge support surface **2531** wherein each forming pocket **2642** can be positioned an equal, or at least substantially equal, distance away from an opposing and corresponding staple support slot **2532**. In various embodiments, the staple cartridge **2600** can comprise staples having the same, or at least substantially the same, initial, unformed staple height and, in addition, the same, or at least substantially the same, formed staple height. In certain other embodiments, the outer rows of staples can comprise staples **2220a** and the inner rows of staples can comprise staples **2220b** wherein, as discussed above, the staples **2220a** and **2220b** can have different unformed staple heights. When the anvil **2640** is moved toward the staple cartridge **2600** into a closed position, the staples **2220a** and **2220b** can be formed such that they have the same, or at least substantially the same, formed staple height. In at least one such embodiment, as a result of the above, the formed outer staples **2220a** and the inner staples **2220b** may have the same, or at least substantially the same, amount of compressible cartridge body **2610** contained therein; however, as the outer staples **2220a** have a taller unformed staple height than the inner staples **2220b** and may have the same formed staple height nonetheless, a greater clamping pressure can be generated in the outer staples **2220a** than the inner staples **2220b**, for example.

In various embodiments, referring now to FIG. **117**, an end effector of a surgical stapler can comprise an anvil **2740**, a staple cartridge channel **2530**, and a staple cartridge **2700** positioned within the staple cartridge channel **2530**. Similar to the above, the staple cartridge **2700** can comprise a compressible, implantable cartridge body **2710** comprising an inner layer **2712**, an outer layer **2711**, and a plurality of staples, such as staples **2220a** and **2220b**, for example, positioned therein. In at least one embodiment, the thickness of the cartridge body **2710** can vary across its width. In at least one such embodiment, the cartridge body **2710** can comprise a center portion **2708** and side portions **2709**, wherein the center portion **2708** can comprise a thickness which is greater than the thickness of the side portions **2709**. In various embodiments, the thickest portion of the cartridge body **2710** can be located at the center portion **2708** while the thinnest portion of the cartridge body **2710** can be located at the side portions **2709**. In at least one such embodiment, the thickness of the cartridge body **2710** can decrease gradually between the center portion **2708** and the side portions **2709**. In certain embodiments, the thickness of the cartridge body **2710** can decrease linearly and/or geometrically between the center portion **2708** and the side portions **2709**. In at least one such embodiment, the tissue-contacting surface **2719** of cartridge body **2710** can comprise two inclined, or angled, surfaces which slope downwardly from the center portion **2708** toward

71

the side portions 2709. In various embodiments, the anvil 2740 can comprise two inclined, or angled, surfaces which parallel, or at least substantially parallel, the inclined tissue-contacting surfaces 2719. In at least one embodiment, the anvil 2740 can further comprise at least one piece of buttress material 2760 attached to the inclined surfaces of the anvil 2740.

In various embodiments, further to the above, the inner rows of staples in the staple cartridge 2700 can comprise the taller staples 2220a and the outer rows of staples can comprise the shorter staples 2220b. In at least one embodiment, the taller staples 2220a can be positioned within and/or adjacent to the thicker center portion 2708 while the staples 2220b can be positioned within and/or adjacent to the side portions 2709. In at least one such embodiment, as a result of the above, the taller staples 2220a can capture more material of the implantable cartridge body 2710 than the shorter staples 2220b. Such circumstances could result in the staples 2220a applying a greater clamping pressure to the tissue T than the staples 2220b. In certain embodiments, even though the taller staples 2220a may capture more material of the cartridge body 2710 therein than the shorter staples 2220b, the taller staples 2220a may have a taller formed staple height than the shorter staples 2220b owing to the inclined arrangement of the staple forming pockets 2742a and 2742b. Such considerations can be utilized to achieve a desired clamping pressure within the tissue captured by the staples 2220a and 2220b wherein, as a result, the clamping pressure in the staples 2220a can be greater than, less than, or equal to the clamping pressure applied to the tissue by the staples 2220b, for example. In various alternative embodiments to the end effector illustrated in FIG. 117, the shorter staples 2220b can be positioned within and/or adjacent to the thicker center portion 2708 of the cartridge body 2710 and the taller staples 2220a can be positioned within and/or adjacent to the thinner side portions 2709. Furthermore, although the staple cartridge 2700 is depicted as comprising inner and outer rows of staples, the staple cartridge 2700 may comprise additional rows of staples, such as staple rows positioned intermediate the inner and outer rows of staples, for example. In at least one such embodiment, the intermediate staple rows can comprise staples having an unformed staple height which is intermediate the unformed staple heights of the staples 2220a and 2220b and a formed staple height which is intermediate the formed staple heights of the staples 2220a and 2220b, for example.

In various embodiments, referring now to FIG. 118, an end effector of a surgical stapler can comprise an anvil 2840, a staple cartridge channel 2530, and a staple cartridge 2800 positioned within the staple cartridge channel 2530. Similar to the above, the staple cartridge 2800 can comprise a compressible, implantable cartridge body 2810 comprising an inner layer 2812, an outer layer 2811, and a plurality of staples, such as staples 2220a and 2220b, for example, positioned therein. In at least one embodiment, the thickness of the cartridge body 2810 can vary across its width. In at least one such embodiment, the cartridge body 2810 can comprise a center portion 2808 and side portions 2809, wherein the center portion 2808 can comprise a thickness which is less than the thickness of the side portions 2809. In various embodiments, the thinnest portion of the cartridge body 2810 can be located at the center portion 2808 while the thickest portion of the cartridge body 2810 can be located at the side portions 2809. In at least one such embodiment, the thickness of the cartridge body 2810 can increase gradually between the center portion 2808 and the side portions 2809. In certain embodiments, the thickness of the cartridge body 2810 can

72

increase linearly and/or geometrically between the center portion 2808 and the side portions 2809. In at least one such embodiment, the tissue-contacting surface 2819 of cartridge body 2810 can comprise two inclined, or angled, surfaces which slope upwardly from the center portion 2808 toward the side portions 2809. In various embodiments, the anvil 2840 can comprise two inclined, or angled, surfaces which parallel, or at least substantially parallel, the inclined tissue-contacting surfaces 2819. In at least one embodiment, the anvil 2840 can further comprise at least one piece of buttress material 2860 attached to the inclined surfaces of the anvil 2840. In various embodiments, further to the above, the outer rows of staples in the staple cartridge 2800 can comprise the taller staples 2220a and the inner rows of staples can comprise the shorter staples 2220b. In at least one embodiment, the taller staples 2220a can be positioned within and/or adjacent to the thicker side portions 2809 while the staples 2220b can be positioned within and/or adjacent to the center portion 2808. In at least one such embodiment, as a result of the above, the taller staples 2220a can capture more material of the implantable cartridge body 2810 than the shorter staples 2220b.

As described above with regard to the embodiment of FIG. 111, for example, the staple cartridge channel 2230 can comprise a stepped support surface 2231 which can be configured to support the staples 2220a and 2220b at different heights with respect to the anvil 2240. In various embodiments, the staple cartridge channel 2230 can be comprised of metal and the steps in the support surface 2231 may be formed in the support surface 2231 by a grinding operation, for example. In various embodiments, referring now to FIG. 119, an end effector of a surgical instrument can comprise a staple cartridge channel 2930 comprising a support insert 2935 positioned therein. More particularly, in at least one embodiment, the staple cartridge channel 2930 can be formed such that it has a flat, or at least substantially flat, support surface 2931, for example, which can be configured to support the insert 2935 which comprises the stepped surfaces for supporting the staples 2220a and 2220b of the staple cartridge 2200 at different heights. In at least one such embodiment, the insert 2935 can comprise a flat, or at least substantially flat, bottom surface which can be positioned against the support surface 2931. The insert 2935 can further comprise support slots, grooves, or troughs 2932a and 2932b which can be configured to support the staples 2220a and 2220b, respectively, at different heights. Similar to the above, the insert 2935 can comprise a knife slot 2939 defined therein which can be configured to permit a cutting member to pass therethrough. In various embodiments, the staple cartridge channel 2930 can be comprised of the same material as or a different material than the support insert 2935. In at least one embodiment, the staple cartridge channel 2930 and the support insert 2935 can both be comprised of metal, for example, while, in other embodiments, the staple cartridge channel 2930 can be comprised of metal, for example, and the support insert 2935 can be comprised of plastic, for example. In various embodiments, the support insert 2935 can be fastened and/or welded into the staple cartridge channel 2930. In certain embodiments, the support insert 2935 can be snap-fit and/or press-fit into the staple cartridge channel 2930. In at least one embodiment the support insert 2935 can be secured in the staple cartridge channel 2930 using an adhesive.

In various embodiments, referring now to FIG. 120, an end effector of a surgical stapler can comprise an anvil 3040, a staple cartridge channel 3030, and a compressible, implantable staple cartridge 3000 positioned in the staple cartridge channel 3030. Similar to the above, the anvil 3040 can com-

prise a plurality of staple-forming pockets **3042** defined therein and a knife slot **3049** which can be configured to slidably receive a cutting member therein. Also similar to the above, the staple cartridge channel **3030** can comprise a plurality of staple support slots **3032** defined therein and a knife slot **3039** which can also be configured to slidably receive a cutting member therein. In various embodiments, the staple cartridge **3000** can comprise a first layer **3011**, a second layer **3012**, and a plurality of staples, such as staples **3020a** and **3020b**, for example, positioned therein. In at least one embodiment, the staples **3020a** can comprise an unformed staple height which is taller than the unformed staple height of the staples **3020b**. In various embodiments, the first layer **3011** can be comprised of a first compressible material and the second layer **3012** can be comprised of a second compressible material. In certain embodiments, the first compressible material can be compressed at a rate which is higher than the second compressible material while, in certain other embodiments, the first compressible material can be compressed at a rate which is lower than the second compressible material. In at least one embodiment, the first compressible material can be comprised of a resilient material which can comprise a first spring rate and the second compressible material can be comprised of a resilient material which can comprise a second spring rate which is different than the first spring rate. In various embodiments, the first compressible material can comprise a spring rate which is greater than the spring rate of the second compressible material. In certain other embodiments, the first compressible material can comprise a spring rate which is less than the spring rate of the second compressible material. In various embodiments, the first compressible layer can comprise a first stiffness and the second compressible layer can comprise a second stiffness, wherein the first stiffness is different than the second stiffness. In various embodiments, the first compressible layer can comprise a stiffness which is greater than the stiffness of the second compressible layer. In certain other embodiments, the first compressible layer can comprise a stiffness which is less than the stiffness of the second compressible layer.

In various embodiments, referring again to FIG. **120**, the second layer **3012** of the staple cartridge **3000** can comprise a constant, or at least substantially constant, thickness across the width thereof. In at least one embodiment, the first layer **3011** can comprise a thickness which varies across the width thereof. In at least one such embodiment, the first layer **3011** can comprise one or more steps **3008** which can increase the thickness of the cartridge body **3010** in certain portions of the cartridge body **3010**, such as the center portion, for example. Referring again to FIG. **120**, the shorter staples **3020b** can be positioned in or aligned with the steps **3008**, i.e., the thicker portions of the cartridge body **3010**, and the taller staples **3020a** can be positioned in or aligned with the thinner portions of the cartridge body **3010**. In various embodiments, as a result of the thicker and thinner portions of the cartridge body **3010**, the stiffness of the cartridge body **3010** can be greater along the inner rows of staples **3020b** than the outer rows of staples **3020a**. In various embodiments, the first layer **3011** can be connected to the second layer **3012**. In at least one such embodiment, the first layer **3011** and the second layer **3012** can comprise interlocking features which can retain the layers **3011** and **3012** together. In certain embodiments, the first layer **3011** can comprise a first laminate and the second layer **3012** can comprise a second laminate, wherein the first laminate can be adhered to the second laminate by one or more adhesives. In various embodiments, the

staple cartridge **3000** can comprise a knife slot **3003** which can be configured to slidably receive a cutting member therein.

In various embodiments, referring now to FIG. **121**, a staple cartridge **3100** can comprise a compressible, implantable cartridge body **3110** comprising a single layer of compressible material and, in addition, a plurality of staples, such as staples **3020b**, for example, positioned therein. In at least one embodiment, the thickness of the cartridge body **3110** can vary across the width thereof. In at least one such embodiment, the cartridge body **3110** can comprise steps **3108** extending along the side portions thereof. In various embodiments, referring now to FIG. **122**, a staple cartridge **3200** can comprise a compressible, implantable cartridge body **3210** comprising a single layer of compressible material and, in addition, a plurality of staples, such as staples **3020b**, for example, positioned therein. In at least one embodiment, the thickness of the cartridge body **3210** can vary across the width thereof. In at least one such embodiment, the cartridge body **3210** can comprise steps **3208** extending along the center portion thereof. In various embodiments, referring now to FIG. **123**, a staple cartridge **3300** can comprise a compressible, implantable cartridge body **3310** wherein, similar to the above, the thickness of the cartridge body **3310** can vary across the width thereof. In at least one embodiment, the thickness of the cartridge body **3310** can increase geometrically between the side portions and the center portion of the cartridge body **3310**. In at least one such embodiment, the thickness of the cartridge body **3310** can be defined by an arcuate or curved profile and can comprise an arcuate or curved tissue-contacting surface **3319**. In certain embodiments, the thickness of the cartridge body **3310**, and the contour of the tissue-contacting surface **3319**, can be defined by one radius of curvature or, alternatively, by several radii of curvature, for example. In various embodiments, referring now to FIG. **124**, a staple cartridge **3400** can comprise a compressible, implantable cartridge body **3410** wherein the thickness of the cartridge body **3410** can increase linearly, or at least substantially linearly, between the side portions and the center portion of the cartridge body **3410**.

In various embodiments, referring now to FIG. **125**, a staple cartridge **3500** can comprise a compressible, implantable cartridge body **3510** and a plurality of staples **3520** positioned therein. The implantable cartridge body **3510** can comprise a first inner layer **3512**, a second inner layer **3513**, and an outer layer **3511**. In at least one embodiment, the first inner layer **3512** can comprise a first thickness and the second inner layer **3513** can comprise a second thickness wherein the second inner layer **3513** can be thicker than the first inner layer **3512**. In at least one alternative embodiment, the first inner layer **3512** can be thicker than the second inner layer **3513**. In another alternative embodiment, the first inner layer **3512** can have the same, or at least substantially the same, thickness as the second inner layer **3513**. In certain embodiments, each staple **3520** can comprise a base **3522** and one or more deformable legs **3521** extending from the base **3522**. In various embodiments, each leg **3521** can comprise a tip **3523** which is embedded in the first inner layer **3511** and, in addition, each base **3522** of the staples **3520** can be embedded in the second inner layer **3512**. In at least one embodiment, the first inner layer **3512** and/or the second inner layer **3513** can comprise at least one medicament stored therein and, in various embodiments, the outer layer **3511** can encapsulate and seal the first inner layer **3512** and the second inner layer **3513** such that the medicament does not flow out of the staple cartridge body **3510** until after the outer layer **3511** has been punctured by the staples **3520**. More particularly, further to

the above, an anvil can be pushed downwardly against tissue positioned against the tissue-contacting surface 3519 of staple cartridge 3500 such that the cartridge body 3510 is compressed and the surface 3519 is moved downwardly toward, and at least partially below, the staple tips 3523 such that the tips 3523 rupture or puncture the outer layer 3511. After the outer layer 3511 has been breached by the staple legs 3521, the at least one medicament M can flow out of the cartridge body 3510 around the staple legs 3521. In various circumstances, additional compression of the cartridge body 3510 can squeeze additional medicament M out of the cartridge body 3510 as illustrated in FIG. 126.

In various embodiments, referring again to FIG. 125, the outer layer 3511 can comprise a water impermeable, or at least substantially impermeable, wrap which can be configured to, one, keep the medicament from prematurely flowing out of the staple cartridge 3500 and, two, prevent fluids within a surgical site, for example, from prematurely entering into the staple cartridge 3500. In certain embodiments, the first inner layer 3512 can comprise a first medicament stored, or absorbed, therein and the second inner layer 3513 can comprise a second medicament stored, or absorbed, therein, wherein the second medicament can be different than the first medicament. In at least one embodiment, an initial compression of the cartridge body 3510, which causes the rupture of the outer layer 3511, can generally express the first medicament out of the first inner layer 3512 and a subsequent compression of the cartridge body 3510 can generally express the second medicament out of the second inner layer 3513. In such embodiments, however, portions of the first medicament and the second medicament may be expressed simultaneously although a majority of the medicament that is initially expressed can be comprised of the first medicament and a majority of the medicament subsequently expressed thereafter can be comprised of the second medicament. In certain embodiments, further to the above, the first inner layer 3512 can be comprised of a more compressible material than the second inner layer 3513 such that the initial compression forces or pressure, which can be lower than the subsequent compression forces or pressure, can cause a larger initial deflection within the first inner layer 3512 than the second inner layer 3513. This larger initial deflection within the first inner layer 3512 can cause a larger portion of the first medicament to be expressed from the first inner layer 3512 than the second medicament from the second inner layer 3513. In at least one embodiment, the first inner layer 3512 can be more porous and/or more flexible than the second inner layer 3513. In at least one such embodiment, the first inner layer 3512 can comprise a plurality of pores, or voids, 3508 defined therein and the second inner layer 3513 can comprise a plurality of pores, or voids, 3509 defined therein wherein, in various embodiments, the pores 3508 can be configured to store the first medicament in the first inner layer 3512 and the pores 3509 can be configured to store the second medicament in the second inner layer 3513. In certain embodiments, the size and density of the pores 3508 within the first inner layer 3512 and the pores 3509 within the second inner layer 3513 can be selected so as to provide a desired result described herein.

In various embodiments, referring again to FIGS. 125 and 126, the outer layer 3511, the first inner layer 3512, and/or the second inner layer 3513 can be comprised of a bioabsorbable material. In at least one embodiment, the first inner layer 3512 can be comprised of a first bioabsorbable material, the second inner layer 3513 can be comprised of a second bioabsorbable material, and the outer layer 3511 can be comprised of a third bioabsorbable material, wherein the first bioabsorbable material, the second bioabsorbable material, and/or the third bio-

absorbable material can be comprised of different materials. In certain embodiments, the first bioabsorbable material can be bioabsorbed at a first rate, the second bioabsorbable material can be bioabsorbed at a second rate, and the third bioabsorbable material can be bioabsorbed at a third rate, wherein the first rate, the second rate, and/or the third rate can be different. In at least one such embodiment, when a material is bioabsorbed at a particular rate, such a rate can be defined as the amount of material mass that is absorbed by a patient's body over a unit of time. As it is known, the bodies of different patients may absorb different materials at different rates and, thus, such rates may be expressed as average rates in order to account for such variability. In any event, a faster rate may be a rate in which more mass is bioabsorbed for a unit of time than a slower rate. In various embodiments, referring again to FIGS. 125 and 126, the first inner layer 3512 and/or the second inner layer 3513 can be comprised of a material which bioabsorbs faster than the material comprising the outer layer 3511. In at least one such embodiment, the first inner layer 3512 and/or the second inner layer 3513 can be comprised of a bioabsorbable foam, tissue sealant, and/or hemostatic material, such as oxidized regenerated cellulose (ORC), for example, and the outer layer 3511 can be comprised of a buttress material and/or plastic material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In such embodiments, the first inner layer 3512 and/or the second inner layer 3513 can immediately treat the tissue and can reduce bleeding from the tissue, for example, wherein the outer layer 3514 can provide longer-term structural support and can be bioabsorbed at a slower rate.

Owing to the slower rate of bioabsorbability of the outer layer 3511, further to the above, the outer layer 3511 can buttress or structurally reinforce the tissue within the staple line as it heals. In certain embodiments, one of the first inner layer 3512 and the second inner layer 3513 can be comprised of a material which can be bioabsorbed faster than the other such that, in at least one embodiment, one of the layers can provide an initial release of a therapeutic material and the other layer can provide a sustained release of the same therapeutic material and/or a different therapeutic material. In at least one such embodiment, the rate in which a therapeutic material can be released from a layer 3512, 3513 can be a function of the bioabsorbability of the substrate layer in which the medicament is absorbed or dispersed. For example, in at least one embodiment, the substrate comprising the first inner layer 3512 can be bioabsorbed faster than the substrate comprising the second inner layer 3513 and, as a result, a medicament can be released from the first inner layer 3512 faster than the second inner layer 3513, for example. In various embodiments, as described herein, one or more of the layers 3511, 3512, and 3513 of the cartridge body 3510 can be adhered to one another by at least one adhesive, such as fibrin and/or protein hydrogel, for example. In certain embodiments, the adhesive can be water soluble and can be configured to release the connection between the layers as the staple cartridge 3500 is being implanted and/or some time thereafter. In at least one such embodiment, the adhesive can be configured to bioabsorb faster than the outer layer 3511, the first inner layer 3512, and/or the second inner layer 3513.

In various embodiments, referring now to FIGS. 127 and 128, a staple cartridge, such as staple cartridge 3600, for example, can comprise a cartridge body 3610 including a

77

compressible first layer **3611**, a second layer **3612** attached to the first layer **3611**, and a removable compressible layer **3613** attached to the second layer **3612**. In at least one such embodiment, the first layer **3611** can be comprised of a compressible foam material, the second layer **3612** can comprise a laminate material adhered to the first layer **3611** utilizing one or more adhesives, and the third layer **3613** can comprise a compressible foam material removably adhered to the second layer **3612** utilizing one or more adhesives, for example. In various embodiments, the staple cartridge **3600** can further comprise a plurality of staples, such as staples **3620**, for example, positioned in the cartridge body **3610**. In at least one such embodiment, each staple **3620** can comprise a base **3622** positioned in the third layer **3613** and one or more deformable legs **3621** extending upwardly from the base **3622** through the second layer **3612** and into the first layer **3611**, for example. In use, further to the above, the top surface **3619** of the staple cartridge body **3610** can be pushed downwardly by an anvil until the staple legs **3621** penetrate through the top surface **3619** and the targeted tissue and contact the anvil. After the staple legs **3621** have been sufficiently deformed, the anvil can be moved away from the staple cartridge **3600** such that the compressible layers thereof can at least partially re-expand. In various circumstances, the insertion of the staples through the tissue can cause the tissue to bleed. In at least one embodiment, the third layer **3613** can be comprised of an absorbent material, such as protein hydrogel, for example, which can draw blood away from the stapled tissue. In addition to or in lieu of the above, the third layer **3613** can be comprised of a hemostatic material and/or tissue sealant, such as freeze-dried thrombin and/or fibrin, for example, which can be configured to reduce the bleeding from the tissue. In certain embodiments, the third layer **3613** may provide a structural support to the first layer **3611** and the second layer **3612** wherein the third layer **3613** may be comprised of a bioabsorbable material and/or a non-bioabsorbable material. In any event, in various embodiments, the third layer **3613** can be detached from the second layer **3612** after the staple cartridge **3610** has been implanted. In embodiments where the third layer **3613** comprises an implantable-quality material, the surgeon can elect whether to remove the third layer **3613** of the cartridge body **3610**. In at least one embodiment, the third layer **3613** can be configured to be removed from the second layer **3612** in one piece.

In various embodiments, the first layer **3611** can be comprised of a first foam material and the third layer **3613** can be comprised of a second foam material which can be different than the first foam material. In at least one embodiment, the first foam material can have a first density and the second foam material can have a second density wherein the first density can be different than the second density. In at least one such embodiment, the second density can be higher than the first density wherein, as a result, the third layer **3613** may be less compressible, or have a lower compression rate, than the first layer **3611**. In at least one alternative embodiment, the first density can be higher than the second density wherein, as a result, the first layer **3611** may be less compressible, or have a lower compression rate, than the third layer **3613**. In various embodiments, referring now to FIGS. **129** and **130**, a staple cartridge **3700**, similar to the staple cartridge **3600**, can comprise a cartridge body **3710** comprising a first compressible foam layer **3711**, a second layer **3712** attached to the first layer **3711**, and a detachable third compressible foam layer **3713** removably attached to the second layer **3712**. In at least one such embodiment, the third layer **3713** can comprise a plurality of staple receiving slots, or cut-outs, **3709** which can each be configured to receive at least a portion of a staple

78

3620, such as a staple base **3622**, for example, therein. In certain embodiments, the staples **3620** can be configured to slide within the staple receiving slots **3709** or, stated another way, the third layer **3713** can be configured to slide relative to the staples **3620** when the staple cartridge **3700** is positioned against the targeted tissue and compressed by an anvil, for example. In at least one embodiment, the receiving slots **3709** can be configured such that there is clearance between the staples **3620** and the side walls of the receiving slots **3709**. In at least one such embodiment, as a result of the above, the staples **3620** may not capture a portion of the third layer **3713** therein when the staples **3620** are deformed, as illustrated in FIGS. **129** and **130**. In certain other embodiments, the ends of the staple receiving slots **3709** adjacent to the second layer **3712** can be closed by a portion of the third layer **3713** and, as a result, at least a portion of the third layer **3713** can be captured within the staples **3620** when they are deformed. In any event, the third layer **3713** can comprise one or more perforations and/or score marks **3708**, for example, which can be configured to permit the third layer **3713** to be removed from the second layer **3712** in two or more pieces as illustrated in FIG. **129**. In FIG. **129**, one of the pieces of the third layer **3713** is illustrated as being removed by a tool **3755**. In various embodiments, the perforations **3708** can be arranged along a line positioned intermediate a first row of staples and a second row of staples.

In various embodiments, referring again to FIGS. **129** and **130**, the bases **3622** of the staples **3620** can be positioned within the receiving slots **3709** wherein, in at least one embodiment, the side walls of the receiving slots **3709** can be configured to contact and releasably retain the staple legs **3621** in position. In certain embodiments, although not illustrated, the third layer **3713** can comprise an elongated slot surrounding all of the staples within a staple line. In at least one such embodiment, a staple cartridge comprising four staple rows, for example, can comprise an elongate slot aligned with each staple row in the bottom layer of the staple cartridge. Further to the above, at least a portion of the staple cartridge **3600** and/or the staple cartridge **3700** can be implanted within a patient and at least a portion of the staple cartridge can be removable from the patient. In at least one embodiment, referring again to FIGS. **129** and **130**, the first layer **3711** and the second layer **3712** can be captured within the staples **3620** and can be implanted with the staples **3620**, whereas the third layer **3713** can be optionally removed or detached from the staple cartridge **3700**. In various circumstances, the removal of a portion of the implanted staple cartridge can reduce the amount of material that the patient's body has to reabsorb which can provide various therapeutic benefits. In the event that a portion of a staple cartridge is detached and removed, such as by a laparoscopic tool **3755**, for example, the detached staple cartridge portion can be removed from the surgical site through a trocar, such as a trocar having a 5 mm aperture, for example. In certain embodiments, a cartridge body can comprise more than one layer that can be removed. For example, the cartridge body **3710** can comprise a fourth layer wherein the third layer of **3713** of the cartridge body **3710** can be comprised of a hemostatic material and the fourth layer can be comprised of a support layer. In at least one such embodiment, a surgeon can remove the support layer and then elect whether to remove the hemostatic layer, for example.

In various embodiments, referring now to FIG. **131**, a staple cartridge, such as staple cartridge **3800**, for example, can comprise a cartridge body **3810** including an outer layer **3811** and an inner layer **3812**. The inner layer **3812** can be comprised of a compressible foam material and the outer

layer **3811** can be at least partially wrapped around the inner layer **3812**. In at least one embodiment, the outer layer **3811** can comprise a first portion **3811a** configured to be positioned on a first side of the inner layer **3812** and a second portion **3811b** configured to be positioned on a second side of the inner layer **3812** wherein the first portion **3811a** and the second portion **3811b** can be connected by a flexible hinge, such as hinge **3809**, for example. In at least one such embodiment, at least one adhesive, such as fibrin and/or protein hydrogel, for example, can be applied to the first side and/or the second side of the inner layer **3812** in order to secure the portions of the outer layer **3811** thereto. In various embodiments, the outer layer **3811** can comprise one or more fastening members extending therefrom. In at least one such embodiment, the outer layer **3811** can comprise a plurality of deformable legs **3821** extending from one side of the outer layer **3811** which can be seated in the compressible inner layer **3812**. In at least one such embodiment, the legs **3821** may not protrude from the second side of the inner layer **3812** while, in at least one alternative embodiment, the legs **3821** may at least partially protrude from the inner layer **3812**. When the compressible cartridge body **3810** is compressed, in use, the legs **3821** can be configured to pierce the inner layer **3812** and the second portion **3811b** of the outer layer **3811**. In certain embodiments, the second portion **3811b** of the outer layer **3811** can comprise apertures, such as apertures **3808**, for example defined therein which can be configured to receive the staple legs **3821**. In certain embodiments, at least portions of the staple cartridge **3800** can comprise a knife slot **3803** which can be configured to slidably receive a cutting member therein. In at least one such embodiment, the knife slot **3803** may not extend entirely through the thickness of the cartridge body **3810** and, as a result, the cutting member may incise the cartridge body **3810** as it is moved relative thereto.

In various embodiments, referring now to FIG. **132**, a staple cartridge **3900** can comprise, similar to staple cartridge **3800**, a cartridge body **3910** including an inner layer **3812** and an outer layer **3811**, wherein the outer layer **3811** can comprise a first portion **3811a** positioned adjacent to the first side of the inner layer **3812** and a second portion **3811b** positioned adjacent to the second side of the inner layer **3812**. In at least one embodiment, similar to the above, the outer layer **3811** can comprise one or more fastening members extending therefrom. In at least one such embodiment, the outer layer **3811** can comprise a plurality of deformable legs **3921** extending from one side of the outer layer **3811** which can be seated in the compressible inner layer **3812**. In certain embodiments, each deformable leg **3921** can comprise at least one hook or barb **3923** protruding therefrom which can be configured to engage the second portion **3811b** of the outer layer **3811** and, as a result, retain the outer layer **3811** to the inner layer **3812**. In at least one such embodiment, the barbs **3923** can be configured to protrude from the second side of the inner layer **3812** and extend through the apertures **3808** in the second portion **3811b** of the outer layer **3811** such that the barbs **3923** can engage the outside surface of the outer layer **3811** and lock the outer layer **3811** to the inner layer **3812**. In order to construct the staple cartridge **3900**, the inner layer **3812** may be at least partially compressed in order to cause the barbs to protrude therefrom and enter into the apertures **3808**. In at least one such embodiment, the staple cartridge **3900** can be at least partially pre-compressed when it is inserted into a staple cartridge, for example. In certain embodiments, further to the above, at least a portion of the legs **3921** can be embedded within the first portion **3811a** of the outer layer **3811** wherein, in at least one embodiment, the outer layer **3811** can be comprised of a plastic material, such

as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example, and the plastic material can be overmolded around at least a portion of the legs **3921**.

In various embodiments, referring now to FIGS. **133-137**, a staple cartridge, such as staple cartridge **4000**, for example, can comprise a cartridge body **4010** including a compressible first layer **4011** and a second layer **4012** and, in addition, a plurality of staples **4020** positioned within the cartridge body **4010**. In certain embodiments, referring to FIG. **135**, each staple **4020** can comprise a base **4022** and at least one deformable leg **4023** extending from the base **4022**. In at least one embodiment, referring to FIG. **133**, the staple cartridge **4000** can be positioned between a staple cartridge channel **4030** and an anvil **4040** of an end effector of a surgical stapler wherein the second layer **4012** of the cartridge body **4010** and/or the bases **4022** of the staples **4020** can be positioned against the staple cartridge channel **4030**. In various embodiments, referring now to FIG. **134**, the second layer **4012** can comprise a layer of pledgets **4060** interconnected to one another by a pledget support frame **4061**. In at least one such embodiment, the pledgets **4060** and the pledget support frame **4061** can be comprised of a molded plastic material, such as polyglycolic acid (PGA), for example. Each pledget **4060** can comprise one or more apertures or slots **4062** which can be configured to receive a staple leg **4021** extending there-through as illustrated in FIGS. **135** and **136**. Each pledget **4060** can further comprise a receiving slot **4063** defined therein which can be configured to receive a base **4022** of a staple **4020**. In various embodiments, referring again to FIG. **134**, the pledgets **4060** and/or pledget support frame **4061** can comprise a plurality of score marks, perforations, or the like which can be configured to allow the pledgets **4060** to become detached from the pledget support frame **4061** at a desired location. Similarly, referring to FIG. **136**, one or more pledgets **4060** can be connected to one another along a line comprising perforations and/or score marks **4064**, for example. In use, the compressible foam layer **4011** can be positioned against the targeted tissue **T** and the cartridge body **4010** can be compressed by the anvil **4040** such that the anvil **4040** can deform the staples **4020**. When the staples **4020** are deformed, the staple legs **4021** of each staple **4020** can capture the tissue **T**, a portion of the first layer **4011**, and a pledget **4060** within the deformed staple. When the staple cartridge channel **4030** is moved away from the implanted staple cartridge **4060**, for example, the pledget support frame **4061** can be detached from the pledgets **4060** and/or the pledgets **4060** can be detached from one another. In certain circumstances, the pledgets **4060** can be detached from the frame **4061** and/or each other when the staples **4020** are being deformed by the anvil **4040** as described above.

In various embodiments described herein, the staples of a staple cartridge can be fully formed by an anvil when the anvil is moved into a closed position. In various other embodiments, referring now to FIGS. **138-141**, the staples of a staple cartridge, such as staple cartridge **4100**, for example, can be deformed by an anvil when the anvil is moved into a closed position and, in addition, by a staple driver system which moves the staples toward the closed anvil. The staple cartridge **4100** can comprise a compressible cartridge body **4110** which can be comprised of a foam material, for example, and a plurality of staples **4120** at least partially positioned within the compressible cartridge body **4110**. In various embodiments, the staple driver system can comprise a driver holder **4160**, a plurality of staple drivers **4162** positioned within the driver holder **4160**, and a staple cartridge pan **4180** which can be configured to retain the staple drivers **4162** in the driver holder **4160**. In at least one such embodiment, the staple

81

drivers **4162** can be positioned within one or more slots **4163** in the driver holder **4160** wherein the sidewalls of the slots **4163** can assist in guiding the staple drivers **4162** upwardly toward the anvil. In various embodiments, the staples **4120** can be supported within the slots **4163** by the staple drivers **4162** wherein, in at least one embodiment, the staples **4120** can be entirely positioned in the slots **4163** when the staples **4120** and the staple drivers **4162** are in their unfired positions. In certain other embodiments, at least a portion of the staples **4120** can extend upwardly through the open ends **4161** of slots **4163** when the staples **4120** and staple drivers **4162** are in their unfired positions. In at least one such embodiment, referring primarily now to FIG. 139, the bases of the staples **4120** can be positioned within the driver holder **4160** and the tips of the staples **4120** can be embedded within the compressible cartridge body **4110**. In certain embodiments, approximately one-third of the height of the staples **4120** can be positioned within the driver holder **4160** and approximately two-thirds of the height of the staples **4120** can be positioned within the cartridge body **4110**. In at least one embodiment, referring to FIG. 138A, the staple cartridge **4100** can further comprise a water impermeable wrap or membrane **4111** surrounding the cartridge body **4110** and the driver holder **4160**, for example.

In use, the staple cartridge **4100** can be positioned within a staple cartridge channel, for example, and the anvil can be moved toward the staple cartridge **4100** into a closed position. In various embodiments, the anvil can contact and compress the compressible cartridge body **4110** when the anvil is moved into its closed position. In certain embodiments, the anvil may not contact the staples **4120** when the anvil is in its closed position. In certain other embodiments, the anvil may contact the legs of the staples **4120** and at least partially deform the staples **4120** when the anvil is moved into its closed position. In either event, the staple cartridge **4100** can further comprise one or more sleds **4170** which can be advanced longitudinally within the staple cartridge **4100** such that the sleds **4170** can sequentially engage the staple drivers **4162** and move the staple drivers **4162** and the staples **4120** toward the anvil. In various embodiments, the sleds **4170** can slide between the staple cartridge pan **4180** and the staple drivers **4162**. In embodiments where the closure of the anvil has started the forming process of the staples **4120**, the upward movement of the staples **4120** toward the anvil can complete the forming process and deform the staples **4120** to their fully formed, or at least desired, height. In embodiments where the closure of the anvil has not deformed the staples **4120**, the upward movement of the staples **4120** toward the anvil can initiate and complete the forming process and deform the staples **4120** to their fully formed, or at least desired, height. In various embodiments, the sleds **4170** can be advanced from a proximal end of the staple cartridge **4100** to a distal end of the staple cartridge **4100** such that the staples **4120** positioned in the proximal end of the staple cartridge **4100** are fully formed before the staples **4120** positioned in the distal end of the staple cartridge **4100** are fully formed. In at least one embodiment, referring to FIG. 140, the sleds **4170** can each comprise at least one angled or inclined surface **4711** which can be configured to slide underneath the staple drivers **4162** and lift the staple drivers **4162** as illustrated in FIG. 141.

In various embodiments, further to the above, the staples **4120** can be formed in order to capture at least a portion of the tissue T and at least a portion of the compressible cartridge body **4110** of the staple cartridge **4100** therein. After the staples **4120** have been formed, the anvil and the staple cartridge channel **4130** of the surgical stapler can be moved away from the implanted staple cartridge **4100**. In various circum-

82

stances, the cartridge pan **4180** can be fixedly engaged with the staple cartridge channel **4130** wherein, as a result, the cartridge pan **4180** can become detached from the compressible cartridge body **4110** as the staple cartridge channel **4130** is pulled away from the implanted cartridge body **4110**. In various embodiments, referring again to FIG. 138, the cartridge pan **4180** can comprise opposing side walls **4181** between which the cartridge body **4110** can be removably positioned. In at least one such embodiment, the compressible cartridge body **4110** can be compressed between the side walls **4181** such that the cartridge body **4110** can be removably retained therebetween during use and releasably disengaged from the cartridge pan **4180** as the cartridge pan **4180** is pulled away. In at least one such embodiment, the driver holder **4160** can be connected to the cartridge pan **4180** such that the driver holder **4160**, the drivers **4162**, and/or the sleds **4170** can remain in the cartridge pan **4180** when the cartridge pan **4180** is removed from the surgical site. In certain other embodiments, the drivers **4162** can be ejected from the driver holder **4160** and left within the surgical site. In at least one such embodiment, the drivers **4162** can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, the drivers **4162** can be attached to the staples **4120** such that the drivers **4162** are deployed with the staples **4120**. In at least one such embodiment, each driver **4162** can comprise a trough configured to receive the bases of the staples **4120**, for example, wherein, in at least one embodiment, the troughs can be configured to receive the staple bases in a press-fit and/or snap-fit manner.

In certain embodiments, further to the above, the driver holder **4160** and/or the sleds **4170** can be ejected from the cartridge pan **4180**. In at least one such embodiment, the sleds **4170** can slide between the cartridge pan **4180** and the driver holder **4160** such that, as the sleds **4170** are advanced in order to drive the staple drivers **4162** and staples **4120** upwardly, the sleds **4170** can move the driver holder **4160** upwardly out of the cartridge pan **4180** as well. In at least one such embodiment, the driver holder **4160** and/or the sleds **4170** can be comprised of a bioabsorbable material, such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, the sleds **4170** can be integrally formed and/or attached to a drive bar, or cutting member, which pushes the sleds **4170** through the staple cartridge **4100**. In such embodiments, the sleds **4170** may not be ejected from the cartridge pan **4180** and may remain with the surgical stapler while, in other embodiments in which the sleds **4170** are not attached to the drive bar, the sleds **4170** may be left in the surgical site. In any event, further to the above, the compressibility of the cartridge body **4110** can allow thicker staple cartridges to be used within an end effector of a surgical stapler as the cartridge body **4110** can compress, or shrink, when the anvil of the stapler is closed. In certain embodiments, as a result of the staples being at least partially deformed upon the closure of the anvil, taller staples, such as staples having an approximately 0.18" staple height, for example, could be used, wherein approximately 0.12" of the staple height can be positioned within the compressible

layer **4110** and wherein the compressible layer **4110** can have an uncompressed height of approximately 0.14", for example.

In various embodiments, referring now to FIGS. **142-145**, a staple cartridge, such as staple cartridge **4200**, for example, can comprise a compressible cartridge body **4210**, a plurality of staples **4220** positioned therein, and a plurality of flexible lateral support members **4234**. In various embodiments, referring now to FIG. **143**, the staple cartridge **4200** can be positioned intermediate an anvil **4240** and a staple cartridge channel **4230** wherein, in at least one embodiment, the lateral support members **4234** can be attached to the staple cartridge channel **4230**. When the anvil **4240** is moved downwardly to compress the cartridge body **4210** and at least partially deform the staples **4220**, as illustrated in FIG. **144**, the side portions of the cartridge body **4210** can bulge laterally and push the lateral support members **4234** outwardly. In at least one such embodiment, the lateral support members **4234** can be attached to the cartridge body **4210** and, when the cartridge body **4210** bulges laterally as described above, the lateral support members **4234** can detach from the cartridge body **4210** as illustrated in FIG. **144**. In at least one embodiment, the lateral support members **4234** can be adhered to the cartridge body **4210** utilizing at least one adhesive, such as fibrin and/or protein hydrogel, for example. Similar to the above, the closing of the anvil **4240** may only partially deform the staples **4220**, wherein the formation of the staples **4220** can be completed by the advancement of one or more sleds **4270** through the staple cartridge **4200** as illustrated in FIG. **145**. In various embodiments, referring now to FIGS. **147** and **148**, the sleds **4270** can be advanced from a proximal end of the staple cartridge **4200** to a distal end of the staple cartridge **4200** by a cutting member **4280**. In at least one such embodiment, the cutting member **4280** can comprise a cutting element, or knife, **4283**, which can be advanced through the tissue **T** and/or the compressible cartridge body **4210**. In certain embodiments, the cutting member **4280** can comprise camming members **4282** which can travel along the outside surfaces of the jaws **4230** and **4240** and move or hold the jaws in position. In various embodiments, as a result of the above, the staples **4220** can be formed into their final shapes at the same time, or at least substantially the same time, as the tissue **T** is incised. In at least one such embodiment, the sleds **4270** can be positioned distally with respect to the knife **4283** such that the tissue **T** is only incised when the proceeding portion of the tissue has been fully stapled, for example.

In various embodiments, referring again to FIGS. **147** and **148**, the sleds **4270** can comprise separate slidable members which are advanced together by the cutting member **4280**. In at least one such embodiment, the sleds **4270** can be contained within the staple cartridge **4200** and the cutting member **4280** can be advanced into the staple cartridge **4200** by a firing bar **4281** such that the cutting member **4280** engages the sleds **4270** and advances the sleds **4270** distally. In certain embodiments, the sleds **4270** can be connected to one another. In either event, each sled **4270** can comprise an angled surface, or cam, **4271** which can be configured to lift the staples **4220** aligned within a staple row. In certain embodiments, the angled surfaces **4271** can be integrally formed with the cutting member **4280**. In at least one embodiment, referring again to FIGS. **147** and **148**, each staple **4200** can comprise a base, at least one deformable member extending from the base, and a crown **4229** overmolded onto and/or positioned around at least a portion of the base and/or the deformable members of the staple **4200**. In various embodiments, such crowns **4229** can be configured to be driven directly by a sled **4270**, for example. More particularly, in at

least one embodiment, the crowns **4229** of staples **4220** can be configured such that the angled surfaces **4271** of the sleds **4270** can slide underneath and directly contact the crowns **4229** without a staple driver positioned therebetween. In such embodiments, each crown **4229** can comprise at least one co-operating angled or inclined surface which can be engaged by an angled surface **4271** of the sleds **4270** such that the co-operating angled surfaces can drive the staples **4220** upwardly when the sleds **4270** are slid underneath the staples **4220**.

In various embodiments, referring now to FIG. **146**, a staple cartridge, such as staple cartridge **4300**, for example, can comprise a compressible body **4310** and a plurality of staples **4320** positioned within the compressible body **4310**. Similar to the above, the staple cartridge **4300** can comprise flexible lateral supports **4334** which can be attached to a staple cartridge channel and/or adhered to the compressible body **4310**. In addition to the above, the flexible lateral supports **4334** can be connected together by one or more struts, or connection members, **4335** which can be configured to hold the lateral supports **4334** together. In use, the connection members **4335** can be configured to prevent, or at least inhibit, the lateral supports **4334** from becoming prematurely detached from the cartridge body **4310**. In certain embodiments, the connection members **4335** can be configured to hold the lateral supports **4334** together after the staple cartridge **4300** has been compressed by an anvil. In such embodiments, the lateral supports **4334** can resist the lateral bulging, or displacement, of the lateral portions of the cartridge body **4310**. In certain embodiments, a cutting member, such as cutting member **4280**, for example, can be configured to transect the connection members **4335** as the cutting member **4280** is moved distally within the cartridge body **4310**. In at least one such embodiment, the cutting member **4280** can be configured to push one or more sleds, such as sleds **4270**, for example, distally in order to form the staples **4320** against an anvil. The sleds **4270** can lead the cutting edge **4283** such that the cutting member **4280** does not transect a connection member **4335** until the staples **4320** adjacent to that connection member **4335** have been fully formed, or at least formed to a desired height. In various circumstances, the connection members **4335**, in co-operation with the lateral supports **4334**, can prevent, or at least reduce, the lateral movement of the compressible cartridge body **4310** and, concurrently, prevent, or at least reduce, the lateral movement of the staples **4320** positioned within the cartridge body **4310**. In such circumstances, the connection members **4335** can hold the staples **4320** in position until after they are deformed and the connection members **4335** can be thereafter cut to release the lateral portions of the cartridge body **4310**. As mentioned above, the lateral supports **4334** can be connected to the staple cartridge channel and, as a result, can be removed from the surgical site with the staple cartridge channel after the staple cartridge **4300** has been implanted. In certain embodiments, the lateral supports **4334** can be comprised of an implantable material and can be left within a surgical site. In at least one embodiment, the connection members **4335** can be positioned intermediate the cartridge body **4310** and the tissue **T** and, after the connection members **4335** have been detached from the lateral supports **4334**, the connection members **4335** can remain implanted in the patient. In at least one such embodiment, the connection members **4335** can be comprised of an implantable material and, in certain embodiments, the connection members **4335** can be comprised of the same material as the lateral supports **4334**, for example. In various embodiments, the connection members **4335** and/or lateral supports **4334** can be comprised of a flexible bioab-

85

sorbable material such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, a connection member can comprise a sheet of material connecting the lateral supports 4334. In certain embodiments, a staple cartridge can comprise connection members extending across the top surface of the cartridge body 4310 and, in addition, connection members extending around the bottom surface of the cartridge body 4310.

In various embodiments, referring now to FIG. 149, a staple cartridge can comprise staples, such as staples 4420, for example, which can comprise a wire portion inserted into a crown portion. In at least one embodiment, the wire portion can be comprised of metal, such as titanium and/or stainless steel, for example, and/or plastic, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example. In at least one embodiment, the crown portion can be comprised of metal, such as titanium and/or stainless steel, for example, and/or plastic, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example. In certain embodiments, the wire portion of each staple 4420 can comprise a base 4422 and deformable legs 4421 extending from the base 4422 wherein the crown portion of each staple 4420 can comprise a crown 4429 which can be configured to receive at least a portion of a base 4422 therein. In order to assemble the portions of each staple 4420, referring now to FIGS. 150A-150C, the legs 4421 of the wire portion can be inserted into an opening 4426 in a crown 4429 wherein the opening 4426 can be configured to guide the legs 4421 into a base chamber 4427. The wire portion can be further inserted into the crown 4429 such that the legs 4421 exit the base chamber 4427 and the base 4422 of the wire portion enters into the base chamber 4427. In at least one such embodiment, the base chamber 4427 can be configured such that the wire portion is rotated within the crown 4429 as the base 4422 enters into the base chamber 4427 such that the staple legs 4421 are pointed in an upward, or at least substantially upward, direction. In various embodiments, referring again to FIG. 149, the crown 4429 can comprise exit holes 4425 which can be configured to receive the staple legs 4421 therein.

In various embodiments, further to the above, a surgical stapler can comprise a sled 4470 configured to transverse the staple cartridge 4400 and staple cartridge channel 4430 and move the staples 4420 contained within the cartridge body 4410 toward an anvil. In various circumstances, the sled 4470 can be moved from a proximal end of the staple cartridge channel 4430 to a distal end of the cartridge channel 4430 in order to implant the cartridge body 4410 and the staples 4420. In certain circumstances, the sled 4470 can be retracted or returned to the proximal end of the cartridge channel 4430 and another staple cartridge 4400 can be inserted into the cartridge channel 4430. Once the new staple cartridge 4400 has been positioned within the cartridge channel 4430, the sled 4470 can be advanced distally once again. In various embodiments, the surgical stapler may comprise one or more lock-out features which can prevent the sled 4470 from being advanced distally once again without a new staple cartridge 4400 being positioned within the cartridge channel 4430. In at least one such embodiment, referring again to FIG. 149, the staple cartridge channel 4430 can comprise a lock-out shoulder 4439 which can be configured to prevent, or at least limit, the distal movement of the sled 4470. More particularly, the sled 4470 can be configured to abut the shoulder 4439 unless

86

the sled 4470 is at least partially lifted upwardly over the shoulder 4439 by a lift feature 4428, for example, extending between the proximal-most staples 4420 within a staple cartridge 4400. Stated another way, absent the presence of the proximal-most staples 4420 in a new staple cartridge 4400, the sled 4470 cannot be advanced. Thus, when an expended staple cartridge 4400 is present within the cartridge channel 4430, or no staple cartridge 4400 is present in the cartridge channel 4430 at all, the sled 4470 cannot be advanced within the cartridge channel 4430.

Further to the above, referring now to FIG. 151, a staple cartridge, such as staple cartridge 4500, for example, can be positioned within a staple cartridge channel 4530 and can comprise a compressible cartridge body 4510, a plurality of staples 4520 positioned within the cartridge body 4510, and a cartridge pan, or retainer, 4580. In various embodiments, the compressible cartridge body 4510 can comprise an outer layer 4511 and an inner layer 4512 wherein, in at least one embodiment, the outer layer 4511 can sealingly enclose the inner layer 4512. In at least one such embodiment, the outer layer 4511 can extend between the inner layer 4512 and the cartridge pan 4580. In certain other embodiments, the outer layer 4511 may only partially surround the inner layer 4512 and, in at least one such embodiment, the outer layer 4511 and the cartridge pan 4580 can co-operate to encompass, or at least substantially encompass, the inner layer 4512. In various embodiments, further to the above, the staples 4520 can be supported by the cartridge pan 4580 wherein the cartridge pan 4580 can comprise one or more staple support channels configured to support the staples 4520. In certain embodiments, the cartridge pan 4580 can be attached to the cartridge body 4510 wherein, in at least one such embodiment, the cartridge body 4510 can be compressed laterally between opposing side walls of the cartridge pan 4580. In various embodiments, the side walls of the cartridge pan 4580 can support the cartridge body 4510 laterally and, in at least one such embodiment, the cartridge pan 4580 can comprise one or more walls, or fins, 4582 extending upwardly from the bottom support 4583 into the cartridge body 4510. In at least one such embodiment, the cartridge body 4510 can comprise one or more slots, or channels, therein which can be configured to receive and/or interlock with the walls 4582. In various embodiments, the walls 4582 can extend partially, or almost entirely, through the cartridge body 4510. In at least one such embodiment, the walls 4582 can extend longitudinally through the staple cartridge 4500 between a first row of staples 4520 and a second row of staples 4520.

In various embodiments, the cartridge body 4510 and/or the cartridge pan 4580 can comprise co-operating retention features which can provide a snap-fit between the cartridge pan 4580 and the cartridge body 4510. In certain embodiments, the staple cartridge 4500 can be positioned within the cartridge channel 4530 such that the cartridge pan 4580 is positioned against and/or attached to the cartridge channel 4530. In at least one embodiment, the cartridge pan 4580 can be detachably coupled to the cartridge channel 4530 such that, after the staple cartridge 4500 has been compressed by the anvil 4540 and the staples 4520 have been deformed, the cartridge pan 4580 can detach from the cartridge channel 4530 and can be implanted with the cartridge body 4510. In at least one such embodiment, the cartridge pan 4580 can be comprised of a bioabsorbable material such as polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA,

PGCL and/or PCL, for example. In certain embodiments, a surgical stapler can further comprise a firing mechanism and/or driver which can be slid intermediate the staple cartridge channel **4530** and a bottom drive surface on the cartridge pan **4580** which can be configured to lift or eject the cartridge pan **4580** from the cartridge channel **4530**. In certain embodiments, the cartridge body **4510** can be detachably coupled to the cartridge pan **4580** such that, after the staple cartridge **4500** has been compressed by the anvil **4540** and the staples **4520** have been deformed, the cartridge body **4510** can detach from the cartridge pan **4580**. In at least one such embodiment, the cartridge pan **4580** can remain fixedly engaged with the cartridge channel **4530** such that the cartridge pan **4580** is removed from the surgical site with the cartridge channel **4530**. In certain embodiments, a surgical stapler can further comprise a firing mechanism and/or driver which can be slid intermediate the staple cartridge pan **4580** and a bottom drive surface on the cartridge body **4510** which can be configured to lift or eject the cartridge body **4510** from the cartridge pan **4580**. In at least one such embodiment, the staple cartridge **4500** can further comprise staple drivers positioned intermediate the cartridge pan **4580** and the staples **4520** such that, as the firing mechanism is slid distally, the staple drivers and the staples **4520** can be driven upwardly toward the anvil. In at least one such embodiment, the staple drivers can be at least partially embedded within the compressible cartridge body **4510**.

In various embodiments, similar to the above, the staple cartridge **4500** can comprise a lock-out feature which can be configured to prevent, or at least limit, the distal movement of a cutting member unless a unfired staple cartridge **4500** has been positioned within the staple cartridge channel **4530**. In certain embodiments, the staple cartridge pan **4580** can comprise a surface which lifts the cutting member upwardly and over a locking surface within the staple cartridge channel **4530**, for example. In the event that a staple cartridge **4500** comprising a cartridge pan **4580** is not present in the cartridge channel **4530**, the cutting member cannot be advanced. In at least one embodiment, the proximal-most staples, and/or any other suitable staples, within a staple cartridge **4500** can comprise a lifting surface which can sufficiently lift the cutting member over the locking surface. In addition to or in lieu of the above, various portions of the staple cartridge **4500** can be comprised of materials having different colors. In such embodiments, a surgeon may be able to visually identify when an unfired and/or fired staple cartridge is present in the staple cartridge channel **4530**. In at least one such embodiment, the outer layer **4511** of the cartridge body **4510** may have a first color, the cartridge pan **4580** may have a second color, and the staple cartridge channel **4530** may have a third color. In the event that the surgeon sees the first color, the surgeon may know that an unfired cartridge **4500** is present in the staple cartridge channel **4530**; in the event that the surgeon sees the second color, the surgeon may know that a fired cartridge **4500** is present in the staple cartridge channel **4530** and that the remaining cartridge pan **4580** needs to be removed; and in the event that the surgeon sees the third color, the surgeon may know that no portion of a staple cartridge **4500** remains within the cartridge channel **4530**.

In various embodiments, referring now to FIG. **152**, a staple cartridge, such as staple cartridge **4600**, for example, can comprise a compressible, implantable cartridge body **4610** and a plurality of staples **4620** positioned therein. The cartridge body **4610** can comprise an outer layer **4611** and an inner layer **4612**. In certain embodiments, the inner layer **4612** can comprise a plurality of pockets, such as pockets, or cavities, **4615**, for example, defined therein which can facili-

tate the collapse of the cartridge body **4610**. In at least one such embodiment, the inner layer **4612** can comprise a corrugated, or honeycomb-configured, lattice which can be configured to withstand a compressive force, or pressure, as long as the compressive force, or pressure, does not exceed a certain threshold value. When the threshold value has not been exceeded, the inner layer **4612** can deform at a linear, or at least substantially linear, rate with respect to the compressive force, or pressure, being applied. After the compressive force, or pressure, has exceeded the threshold value, the inner layer **4612** can suddenly succumb to large deflections and collapse, or buckle, as a result of the compressive load. In various embodiments, the lattice of the inner layer **4612** can be comprised of a plurality of sub-layers **4612a** which can be connected together. In at least one embodiment, each sub-layer **4612a** can comprise a plurality of alternating furrows and ridges, or waves, which can be aligned with the alternating furrows and ridges of an adjacent sub-layer **4612a**. In at least one such embodiment, the furrows of a first sub-layer **4612a** can be positioned adjacent to the ridges of a second sub-layer **4612a** and, similarly, the ridges of the first sub-layer **4612a** can be positioned adjacent to the furrows of the second sub-layer **4612a**. In various embodiments, the adjacent sub-layers **4612a** can be adhered to one another and/or the outer layer **4611** by at least one adhesive, such as fibrin and/or protein hydrogel, for example. FIG. **153** illustrates the staple cartridge **4600** after the cartridge body **4610** has been collapsed and the staples **4620** have been deformed in order to capture and hold tissue **T** against the cartridge body **4610**.

In various embodiments, referring now to FIGS. **154-156**, a staple cartridge, such as staple cartridge **4700**, for example, can comprise a compressible, implantable cartridge body **4710** and a plurality of staples **4720** positioned within the cartridge body **4710**. Similar to the above, the cartridge body **4710** can comprise an outer layer **4711** and an inner layer **4712**, wherein the inner layer **4712** can comprise a plurality of sub-layers **4712a**. Also similar to the above, each sub-layer **4712a** can comprise alternating furrows **4717** and ridges **4718** which can be aligned with one another to define pockets, or cavities, **4715** therebetween. In at least one such embodiment, the furrows **4717** and/or the ridges **4718** can extend along axes which are parallel to one another and/or parallel to a longitudinal axis **4709**. In various embodiments, the staples **4720** can be aligned in a plurality of staple rows which can extend along axes which are parallel to one another and/or parallel to the longitudinal axis **4709**. In various alternative embodiments, referring again to FIGS. **152** and **153**, the staples **4620** contained in the cartridge body **4600** can extend along axes which are traverse or perpendicular with respect to the axes defined by the furrows and ridges of the sub-layers **4612a**. Referring again to FIGS. **154-156**, the staples **4720** can extend through the furrows **4717** and the ridges **4718** wherein friction forces between the staples **4720** and the sub-layers **4712a** can hold the staples **4720** within the cartridge body **4710**. In certain embodiments, the plurality of sub-layers **4712a** can be comprised of a buttress material and/or plastic material, such as polydioxanone (PDS) and/or polyglycolic acid (PGA), for example, which can be configured to hold the staples **4720** in an upright orientation, for example, and/or hold the staples **4720** in alignment with respect to each other as illustrated in FIGS. **154** and **155**. FIG. **156** illustrates the staple cartridge **4700** after the cartridge body **4710** has been collapsed and the staples **4720** have been deformed in order to capture and hold tissue **T** against the cartridge body **4710**.

In various embodiments, referring again to FIGS. **154-156**, the cartridge body **4710** can resiliently or elastically collapse

when it is compressed. In at least one such embodiment, the waves formed within each sub-layer 4712a by the furrows 4717 and the ridges 4718 can be flattened, or at least substantially flattened, when the cartridge body 4710 is compressed which can collapse, or at least substantially collapse, the cavities 4715 defined therebetween. In various circumstances, the cartridge body 4710, or at least portions of the cartridge body 4710, can resiliently or elastically re-expand after the compressive force, or pressure, has been removed from the cartridge body 4710. In at least one such embodiment, the connections between the furrows 4717 and the ridges 4718 of adjacent sub-layers 4712a can remain intact, or at least substantially intact, when the cartridge body 4710 is compressed such that, after the compression force has been removed from the cartridge body 4710, the sub-layers 4712a can bias themselves away from each other and, as a result, at least partially re-expand the cartridge body 4710. In certain embodiments, the cartridge body 4710 can be plastically deformed, or crushed, when it is compressed and, as a result, the cartridge body 4710 may not re-expand after the compressive force, or pressure, has been removed from the cartridge body 4710. In certain embodiments, referring now to FIG. 157, a staple cartridge, such as staple cartridge 4800, for example, can comprise a crushable cartridge body 4810 comprising an outer layer 4811 and an inner layer 4812, wherein the inner layer 4812 can comprise a corrugated, honeycomb-configured, lattice having a plurality of pockets, or cavities, 4815 defined therein. In various embodiments, the walls defining the lattice of inner layer 4812 can comprise one or more weakened, or thin, cross-sections 4819 which can be configured to allow the walls defining the lattice to break when the cartridge body 4810 is compressed. In such circumstances, the cartridge body 4810 can be crushed when the staple cartridge 4800 is implanted.

In various embodiments, referring now to FIGS. 158-160, a staple cartridge, such as staple cartridge 4900, for example, can comprise a cartridge body 4910 comprising an outer layer 4911 and a plurality of collapsible elements 4912 positioned intermediate top and bottom portions of the outer layer 4911, for example. Referring primarily to FIGS. 158 and 159, the staple cartridge 4900 can further comprise a plurality of staples 4920, wherein each staple 4920 can be positioned in a collapsible element 4912. More particularly, each collapsible element 4912 can comprise a first portion 4912a, a second portion 4912b, and a third portion 4912c which can co-operate to define a cavity 4915 therein which is configured to receive a staple 4920. In use, further to the above, the staple cartridge 4900 can be positioned within a staple cartridge channel and a compressive force can be applied to the tissue contacting surface 4919 in order to compress the cartridge body 4910. As the tissue contacting surface 4919 is moved downwardly, the collapsible elements 4912 can collapse. In such circumstances, the second portion 4912b of each collapsible element 4912 can collapse into a corresponding first portion 4912a and, similarly, the third portion 4912c of each collapsible element 4912 can collapse into a corresponding second portion 4912b. As the cartridge body 4910 is compressed and the collapsible elements 4912 are collapsed, the staples 4920 positioned within the collapsible elements 4912 can be deformed, as illustrated in FIG. 160. In various embodiments, the second portion 4912b of each collapsible element 4912 can be frictionally engaged and/or press-fit within a corresponding first portion 4912a such that, once the compressive force applied to the collapsible element 4912 exceeds the retention force retaining the first portion 4912a and the second portion 4912b in their extended position (FIG. 159), the first portion 4912a and the second portion 4912b can

begin to slide relative to one another. Similarly, the third portion 4912c of each collapsible element 4912 can be frictionally engaged and/or press-fit within a corresponding second portion 4912b such that, once the compressive force applied to the collapsible element 4912 exceeds the retention force retaining the second portion 4912b and the third portion 4912c in their extended position (FIG. 159), the second portion 4912b and the third portion 4912c can begin to slide relative to one another.

In many embodiments described herein, a staple cartridge can comprise a plurality of staples therein. In various embodiments, such staples can be comprised of a metal wire deformed into a substantially U-shaped configuration having two staple legs. Other embodiments are envisioned in which staples can comprise different configurations such as two or more wires that have been joined together having three or more staple legs. In various embodiments, the wire, or wires, used to form the staples can comprise a round, or at least substantially round, cross-section. In at least one embodiment, the staple wires can comprise any other suitable cross-section, such as square and/or rectangular cross-sections, for example. In certain embodiments, the staples can be comprised of plastic wires. In at least one embodiment, the staples can be comprised of plastic-coated metal wires. In various embodiments, a cartridge can comprise any suitable type of fastener in addition to or in lieu of staples. In at least one such embodiment, such a fastener can comprise pivotable arms which are folded when engaged by an anvil. In certain embodiments, two-part fasteners could be utilized. In at least one such embodiment, a staple cartridge can comprise a plurality of first fastener portions and an anvil can comprise a plurality of second fastener portions which are connected to the first fastener portions when the anvil is compressed against the staple cartridge. In certain embodiments, as described above, a sled or driver can be advanced within a staple cartridge in order to complete the forming process of the staples. In certain embodiments, a sled or driver can be advanced within an anvil in order to move one or more forming members downwardly into engagement with the opposing staple cartridge and the staples, or fasteners, positioned therein.

In various embodiments described herein, a staple cartridge can comprise four rows of staples stored therein. In at least one embodiment, the four staple rows can be arranged in two inner staple rows and two outer staple rows. In at least one such embodiment, an inner staple row and an outer staple row can be positioned on a first side of a cutting member, or knife, slot within the staple cartridge and, similarly, an inner staple row and an outer staple row can be positioned on a second side of the cutting member, or knife, slot. In certain embodiments, a staple cartridge may not comprise a cutting member slot; however, such a staple cartridge may comprise a designated portion configured to be incised by a cutting member in lieu of a staple cartridge slot. In various embodiments, the inner staple rows can be arranged within the staple cartridge such that they are equally, or at least substantially equally, spaced from the cutting member slot. Similarly, the outer staple rows can be arranged within the staple cartridge such that they are equally, or at least substantially equally, spaced from the cutting member slot. In various embodiments, a staple cartridge can comprise more than or less than four rows of staples stored within a staple cartridge. In at least one embodiment, a staple cartridge can comprise six rows of staples. In at least one such embodiment, the staple cartridge can comprise three rows of staples on a first side of a cutting member slot and three rows of staples on a second side of the cutting member slot. In certain embodiments, a staple cartridge may

comprise an odd number of staple rows. For example, a staple cartridge may comprise two rows of staples on a first side of a cutting member slot and three rows of staples on a second side of the cutting member slot. In various embodiments, the staple rows can comprise staples having the same, or at least substantially the same, unformed staple height. In certain other embodiments, one or more of the staple rows can comprise staples having a different unformed staple height than the other staples. In at least one such embodiment, the staples on a first side of a cutting member slot may have a first unformed height and the staples on a second side of a cutting member slot may have a second unformed height which is different than the first height, for example.

In various embodiments, referring now to FIGS. 161A-161D, an end effector of a surgical stapler can comprise a cartridge attachment portion, such as staple cartridge channel 5030, for example, a fastener cartridge removably positioned in the staple cartridge channel 5030, such as staple cartridge 5000, for example, and a jaw 5040 positioned opposite the staple cartridge 5000 and the staple cartridge channel 5030. The staple cartridge 5000 can comprise a compressible body 5010 and a plurality of staples 5020, and/or any other suitable fasteners, at least partially positioned in the compressible body 5010. In at least one such embodiment, each staple 5020 can comprise a base 5022 and, in addition, legs 5021 extending upwardly from the base 5022, wherein at least a portion of the legs 5021 can be embedded in the cartridge body 5010. In various embodiments, the compressible body 5010 can comprise a top, or tissue-contacting, surface 5019 and a bottom surface 5018, wherein the bottom surface 5018 can be positioned against and supported by a support surface 5031 of the staple cartridge channel 5030. Similar to the above, the support surface 5031 can comprise a plurality of support slots 5032 (FIG. 161D), for example, defined therein which can be configured to receive and support the bases 5022 of the staples 5020. In various embodiments, the end effector of the surgical stapler can further comprise a retention matrix, such as retention matrix 5050, for example, which can be configured to engage the staples 5020 and capture tissue therebetween. In at least one such embodiment, the retention matrix 5050 can be removably mounted to the jaw 5040. In use, once the staple cartridge 5000 has been positioned within the staple cartridge channel 5030, the jaw 5040, and the retention matrix 5050 attached thereto, can be moved toward the staple cartridge 5000 and the staple cartridge channel 5030. In at least one embodiment, the jaw 5040 can be moved downwardly along an axis 5099 such that the jaw 5040 and the staple cartridge channel 5030 remain parallel, or at least substantially parallel, to one another as the jaw 5040 is closed. More particularly, in at least one such embodiment, the jaw 5040 can be closed in a manner such that a tissue-contacting surface 5051 of the retention matrix 5050 is parallel, or at least substantially parallel, to the tissue-contacting surface 5019 of the staple cartridge 5000 as the jaw 5040 is moved toward the staple cartridge 5000.

In various embodiments, referring now to FIG. 161A, the retention matrix 5050 can be detachably secured to the jaw 5040 such that there is little, if any, relative movement between the retention matrix 5050 and the jaw 5040 when the retention matrix 5050 is attached to the jaw 5040. In at least one embodiment, the jaw 5040 can comprise one or more retention features which can be configured to hold the retention matrix 5050 in position. In at least one such embodiment, the retention matrix 5050 can be snap-fit and/or press-fit into the jaw 5040. In certain embodiments, the retention matrix 5050 can be adhered to the jaw 5040 utilizing at least one adhesive. In any event, the jaw 5040 can be moved into a

position in which the retention matrix 5050 is in contact with the tissue T and the tissue T is positioned against the tissue-contacting surface 5019 of the staple cartridge 5000. When the tissue T is positioned against the staple cartridge 5000 by the jaw 5040, the compressible body 5010 of the staple cartridge 5000 may or may not be compressed by the jaw 5040. In either circumstance, in various embodiments, the legs 5021 of the staples 5020 may not protrude through the tissue-contacting surface 5019 of the staple cartridge 5000 as illustrated in FIG. 161A. Furthermore, as also illustrated in FIG. 161A, the jaw 5040 can hold the tissue T against the compressible body 5010 without engaging the retention matrix 5050 with the staples 5020. Such embodiments can permit a surgeon to open and close the jaw 5040 multiple times in order to obtain a desired positioning of the end effector within a surgical site, for example, without damaging the tissue T. Other embodiments are envisioned, however, where the staple tips 5023 can protrude from the tissue-contacting surface 5019 prior to the cartridge body 5010 being compressed by the anvil 5040. Once the end effector has been suitably positioned, referring now to FIG. 161B, the jaw 5040 can be moved downwardly toward the staple cartridge channel 5030 such that the compressible body 5010 is compressed by the anvil 5040 and such that the tissue-contacting surface 5019 is pushed downwardly relative to the staples 5020. As the tissue-contacting surface 5019 is pushed downwardly, the tips 5023 of the staple legs 5021 can pierce the tissue-contacting surface 5019 and pierce at least a portion of the tissue T. In such circumstances, the retention matrix 5050 may be positioned above the staples 5020 such that the retention apertures 5052 of retention matrix 5050 are aligned, or at least substantially aligned, with the tips 5023 of the staple legs 5021.

As the retention matrix 5050 is pushed downwardly along the axis 5099, referring now to FIG. 161C, the staple legs 5021 of staples 5020 can enter into the retention apertures 5052. In various embodiments, the staple legs 5021 can engage the side walls of the retention apertures 5052. In certain embodiments, as described in greater detail below, the retention matrix 5050 can comprise one or more retention members extending into and/or around the retention apertures 5052 which can engage the staple legs 5021. In either event, the staple legs 5021 can be retained in the retention apertures 5052. In various circumstances, the tips 5023 of the staple legs 5021 can enter into the retention apertures 5052 and can frictionally engage the retention members and/or the side walls of the apertures 5052. As the retention matrix 5050 is pushed toward the bases 5022 of the staples 5020, the staple legs 5021 can slide relative to the side walls and/or the retention members. As a result of the above, sliding friction forces can be created between the staple legs 5021 and the retention matrix 5050 wherein such sliding friction forces can resist the insertion of the retention matrix 5050 onto the staples 5020. In various embodiments, the sliding friction forces between the retention matrix 5050 and the staples 5020 can be constant, or at least substantially constant, as the retention matrix 5050 is slid downwardly along the staple legs 5021 of the staples 5020. In certain embodiments, the sliding friction forces may increase and/or decrease as the retention matrix 5050 is slid downwardly along the staple legs 5021 owing to variations in geometry of the staple legs 5021, the retention apertures 5052, and/or the retention members extending into and/or around the retention apertures 5052, for example. In various embodiments, the insertion of the retention matrix 5050 onto the staples 5020 can also be resisted by the compressible body 5010 of the staple cartridge 5000. More particularly, the compressible body 5010 can be comprised of an elastic material, for example, which can apply a resistive

force to the retention matrix **5050** which increases as the distance in which the compressible body **5010** is compressed increases. In at least one such embodiment, the increase in the resistive force generated by the cartridge body **5010** can be linearly proportional, or at least substantially linearly proportional, with respect to the distance in which the cartridge body **5010** is compressed. In certain embodiments, the increase in the resistive force generated by the cartridge body **5010** can be geometrically proportional with respect to the distance in which the cartridge body **5010** is compressed.

In various embodiments, further to the above, a sufficient firing force can be applied to the jaw **5040** and the retention matrix **5050** in order to overcome the resistive and friction forces described above. In use, the retention matrix **5050** can be seated to any suitable depth with respect to the staples **5020**. In at least one embodiment, the retention matrix **5050** can be seated to a depth with respect to the bases **5022** of the staples **5020** in order to secure two or more layers of tissue together and generate compressive forces, or pressure, within the tissue. In various circumstances, the system comprising the retention matrix **5050** and the staples **5020** can allow a surgeon to select the amount of compressive forces, or pressure, that is applied to the tissue by selecting the depth in which the retention matrix **5050** is seated. For example, the retention matrix **5050** can be pushed downwardly toward the staple bases **5022** of the staples **5020** until the retention matrix **5050** is seated a certain depth **5011** away from the bottom of the support slots **5032**, wherein a shorter depth **5011** can result in higher compressive forces, or pressure, being applied to the tissue T than a taller depth **5011** which can result in lower compressive forces, or pressure, being applied to the tissue T. In various embodiments, the compressive forces, or pressures, applied to the tissue T can be linearly proportional, or at least substantially linearly proportional, to the depth **5011** in which the retention matrix **5050** is seated. In various circumstances, the compressive forces, or pressure, applied to the tissue T can depend on the thickness of the tissue T positioned between the retention matrix **5050** and the staple cartridge **5020**. More particularly, for a given distance **5011**, the presence of thicker tissue T can result in higher compression forces, or pressure, than the presence of thinner tissue T.

In various circumstances, further to the above, a surgeon can adjust the depth in which the retention matrix **5050** is seated in order to account for thicker and/or thinner tissue positioned within the end effector and to apply a certain or predetermined pressure to the tissue T regardless of the tissue thickness. For example, the surgeon can seat the retention matrix **5050** to a shorter depth **5011** when fastening thinner tissue T or a taller depth **5011** when fastening thicker tissue T in order to arrive at the same, or at least substantially the same, compression pressure within the tissue. In certain embodiments, further to the above, a surgeon can selectively determine the amount of compressive pressure to apply to the tissue T positioned between the retention matrix **5050** and the staple cartridge **5010**. In various circumstances, a surgeon can engage the retention matrix **5050** with the staples **5020** and position the retention matrix **5050** a first distance away from the bases **5022** of the staples **5020** in order to apply a first compressive pressure to the tissue. The surgeon can alternatively position the retention matrix **5050** a second distance away from the bases **5022**, which is shorter than the first distance, in order to apply a second compressive pressure to the tissue which is greater than the first pressure. The surgeon can alternatively position the retention matrix **5050** a third distance away from the bases **5022**, which is shorter than the second distance, in order to apply a third compressive pressure to the tissue which is greater than the second pressure. In

various embodiments, the fastening system comprising the retention matrix **5050** and the staples **5020** can be configured to permit a surgeon to apply a wide range of compressive pressures to the targeted tissue.

In various embodiments, referring now to FIG. **161D**, the staple legs **5021** can be inserted through the retention matrix **5050** such that the staple leg tips **5023** extend above the top surface of the retention matrix **5050**. In at least one embodiment, referring again to FIG. **161C**, the jaw **5040** can further comprise clearance apertures **5042** defined therein which can be configured to receive the staple leg tips **5023** as they pass through the retention apertures **5052** in the retention matrix **5050**. In at least one such embodiment, the clearance apertures **5042** can be aligned with the retention apertures **5052** such that the legs **5021** do not contact the jaw **5040**. In various embodiments, the clearance apertures **5042** can have a sufficient depth such that the staple legs **5021** do not contact the jaw **5040** regardless of the distance in which the retention matrix **5050** is seated. After the retention matrix **5050** has been engaged with the staples **5020** and seated to a desired position, referring now to FIG. **161D**, the staple cartridge channel **5030** and the jaw **5040** can be moved away from the tissue T. More particularly, the staple cartridge channel **5030** can be detached from the implanted staple cartridge **5000** and the anvil **5040** can be detached from the implanted retention matrix **5050**. As the jaw **5040** is moved away from the retention matrix **5050** and the staple supports **5032** are moved away from the staple bases **5022**, the distance **5011** between the retention matrix **5050** and the bottom of the bases **5022** can be maintained even though the jaw **5040** and the staple cartridge channel **5030** are no longer providing support thereto. In various embodiments, the static friction forces between the staple legs **5021** and the retention matrix **5050** can be sufficient to maintain the retention matrix **5050** in position despite a biasing force being applied to the retention matrix **5050** by the compressed cartridge body **5010** and/or the compressed tissue T. In at least one such embodiment, the cartridge body **5010** can be comprised of a resilient material which, when compressed, can apply an elastic biasing force to the retention matrix **5050** and the staples **5020** in a manner which tends to push the retention matrix **5050** and the staples **5020** apart, although such movement is opposed by the frictional engagement between the staple legs **5021** and the retention matrix **5050**.

In various embodiments, as described above, a retention matrix can comprise a plurality of retention apertures, wherein each retention aperture can be configured to receive a leg of a fastener therein. In at least one embodiment, referring now to FIG. **162**, a portion of a retention matrix **5150** is illustrated therein which can comprise a retention aperture **5152** defined by a perimeter **5156**. In various embodiments, the perimeter **5156** of the aperture **5152** can comprise a circular, or at least substantially circular, profile and/or any other suitable profile. In certain embodiments, the retention matrix **5150** can comprise one or more retention members, such as retention members **5153**, for example, which extend into the aperture **5152** and can be configured to engage a fastener leg when the fastener leg is inserted therethrough. In at least one such embodiment, each retention member **5153** can comprise a cantilever which extends inwardly toward a center axis **5159**, i.e., toward the center of the aperture **5152**. In various embodiments, each cantilever can comprise a first end which is attached to the retention matrix body **5158** and a second end which forms the perimeter **5156** of the retention aperture **5152**. In certain embodiments, the perimeter **5156** of a retention aperture **5152** can be defined by a first diameter, or width, and a fastener leg can be defined by a second diameter, or

width, wherein the second diameter can be larger than the first diameter. In at least one such embodiment, the fastener leg can be configured to contact and deflect one or more of the retention members **5153** in order to increase the diameter of the retention aperture **5152** as the fastener leg is being inserted therethrough. In certain embodiments, further to the above, the fastener leg can define a perimeter which is larger than the perimeter **5156** of the retention aperture **5152** such that the fastener leg can expand the perimeter **5156** when the fastener leg is inserted therein.

In various embodiments, referring again to FIG. **162**, the aperture **5152** can be defined by the deformable members **5153**, wherein each deformable member **5153** can be configured to deflect relative to, or independently of, the other deformable members **5153**. In at least one such embodiment, adjacent deformable members **5153** can be separated by slots **5154** which can be configured to permit each deformable member **5153** to flex relative to the others. In certain embodiments, each slot **5154** can comprise a first end **5155** in the retention matrix body **5158**, a second end opening into the retention aperture **5152**, and a constant, or at least substantially constant, width extending between the first end **5155** and the second end. In various other embodiments, the width of each slot **5154** may not be constant and each slot **5154** may increase and/or decrease in width between the first and second ends thereof. In certain embodiments, the first ends **5155** of the slots **5154** can comprise an enlarged portion, such as a circular portion, which can provide, one, strain relief to the bases of the deformable members **5153** attached to the retention matrix body **5158** and, two, means for increasing the flexibility of the deformable members **5153**. In various embodiments, the geometry of the deformable members **5153**, and/or slots **5154**, can be selected so as to provide the deformable members **5153** with a desired flexibility. In certain embodiments, for example, the slots **5154** can be lengthened in order to create longer deformable members **5153** which can be more flexible than deformable members **5153** having a shorter length. In at least one embodiment, the width of each deformable member **5153** can be selected so as to provide a desired flexibility thereof. More particularly, deformable members having a thinner width can be more flexible than deformable members having a thicker width. In certain embodiments, referring again to FIG. **162**, the first ends of the cantilevers of deformable members **5153** attached to the retention matrix body **5158** can be wider than the second ends of the cantilevers. In at least one such embodiment, the cantilevers can be tapered in a linear, or at least substantially linear, manner between the first and second ends thereof.

In various embodiments, referring again to FIG. **162**, the retention matrix body **5158** can comprise a flat, or at least substantially flat, sheet of material having a tissue-contacting surface **5151** and a top surface **5157**. In at least one such embodiment, the tissue-contacting surface **5151** and the top surface **5157** can be parallel, or at least substantially parallel, to one another. In various embodiments, each deformable member **5153** can comprise a first portion **5153a** and a second portion **5153b**, wherein the first portion **5153a** can extend in a first direction and the second portion **5153b** can extend in a different, or second, direction. In at least one such embodiment, the retention matrix body **5158** can define a plane and the first portions **5153a** of the deformable members **5153** can lie within such a plane. In various embodiments, the second portions **5153b** of the deformable members **5153** can extend at an angle relative to the first portions **5153a**. In at least one such embodiment, the second portions **5153b** can extend in directions which are pointed away from the top surface **5157**

of the retention matrix body **5158** and, in certain embodiments, the second portions **5153b** can converge toward the central axis **5159** of the retention aperture **5152**. In any event, in various embodiments, the second portions **5153b** can be configured to deflect away from the central axis **5159** when the fastener leg is inserted therethrough. In embodiments where a staple leg **5021** of a staple **5020** is inserted into a retention aperture **5152**, the deformable members **5153** can deform in a direction which is generally away from the bases **5122** of the staples **5120**. In certain embodiments, as a result, the deformable members **5153** can deflect in a general direction which is the same as, or at least substantially the same as, the direction in which the staple legs **5021** are being inserted.

In various embodiments, referring again to FIG. **162**, the second portions **5153b** of the deformable members **5153** can each comprise a sharp tip, for example, which can be configured to slide against a staple leg **5021** as the staple leg **5021** is inserted therein. The sharp tips of the second portions **5153b** can also be configured to bite into the staple leg **5021** in the event that the staple leg **5021** were to be pulled in the opposite direction, i.e., in a direction which would remove the staple leg **5021** from the retention aperture **5052**. In certain circumstances, the second portions **5153b** can be inclined at an angle relative to the side of the staple leg **5021** which is greater than 90 degrees and, as a result, the second portions **5153b** may dig, or burrow, into the side of the staple leg **5021** when the staple leg **5021** experiences a force which tends to withdraw the staple leg **5021** from the retention aperture **5052**. In certain embodiments, the staple legs **5021** can comprise indentations and/or concavities, such as microindentations, for example, in the surfaces thereof which can be configured to receive the tips of the deformable members **5053**, for example, therein. In at least one such embodiment, the tips of the deformable members **5053** can catch in and burrow into the indentations in the staple legs **5021** when a withdrawing force is applied to the staple legs **5021**. In various embodiments, as a result of the burrowing of the second portions **5153b** into the staple legs **5021**, forces acting to remove the staple legs **5021** from the retention apertures **5152** may only seat the second portions **5153b** deeper into the staple legs **5021** and increase the force required to remove the staple legs **5021**. Furthermore, owing to the upward inclination of the second portions **5153b**, in at least one embodiment, the second portions **5153b** can be more permissive to the insertion of a staple leg **5021** within a retention aperture **5152** and more resistive to withdrawal of the staple leg **5021**. In at least one embodiment, as a result, the force required to insert a staple leg **5021** into a retention aperture **5152** may be less than the force required to remove the staple leg **5021** from the retention aperture **5152**. In various embodiments, the force needed to remove the staple leg **5021** from the retention aperture **5152** can be approximately 50 percent greater than the force needed to insert the staple leg **5021** into the retention aperture **5152**, for example. In various other embodiments, the force needed to remove the staple leg **5021** may be between approximately 10 percent and approximately 100 percent greater than the force needed to insert the staple leg **5021**, for example. In certain embodiments, the force needed to remove the staple leg **5021** may be approximately 100 percent, approximately 150 percent, approximately 200 percent, and/or greater than approximately 200 percent larger than the force needed to insert the staple leg **5021**, for example.

In certain embodiments, referring again to FIG. **162**, the second portions **5153b** can be arranged circumferentially around the aperture **5152** and can define a pocket therebetween. More particularly, the second portions **5153b** can define a pocket **5160** which can be configured to receive the

tip of the fastener leg when it is inserted into the retention aperture **5152**. In various embodiments, the second portions **5153b** of the deformable members **5153** can comprise an annular, or an at least substantially annular, contour which can co-operatively define an annular, or at least substantially annular, profile of the pocket **1560**, for example. In at least one such embodiment, the second portions **5153b** can define a conical or frustoconical pocket. In various embodiments, the pocket can be defined by a suitable number of deformable members, such as four deformable members **5153** (FIG. **162**), six deformable members **5153** (FIG. **163**), or eight deformable members **5153** (FIG. **164**), for example. In certain embodiments, referring now to FIG. **165**, the deformable members of a retention matrix, such as retention matrix **5250**, for example, can form a pyramidal shape, or an at least substantially pyramidal shape, for example. In various embodiments, a retention matrix **5250** can comprise a plurality of retention apertures, such as retention aperture **5252**, for example, which can be defined by a perimeter **5256**. In various embodiments, the perimeter **5256** can comprise a polygonal, or at least substantially polygonal, profile and/or any other suitable profile. In certain embodiments, the retention matrix **5250** can comprise one or more retention members, such as retention members **5253**, for example, which extend into the aperture **5252** and can be configured to engage a fastener leg when the fastener leg is inserted therethrough. In at least one such embodiment, each retention member **5253** can comprise a cantilever which extends inwardly toward a center axis **5259**, i.e., toward the center of the aperture **5252**. In various embodiments, each cantilever can comprise a first end which is attached to the retention matrix body **5258** and a second end which forms the perimeter **5256** of the retention aperture **5252**. In certain embodiments, the perimeter **5256** of a retention aperture **5252** can be defined by a first diameter, or width, and a fastener leg can be defined by a second diameter, or width, wherein the second diameter can be larger than the first diameter. In at least one such embodiment, the fastener leg can be configured to contact and deflect one or more of the retention members **5253** in order to increase the diameter of the retention aperture **5252** as the fastener leg is being inserted therethrough. In certain embodiments, further to the above, the fastener leg can define a perimeter which is larger than the perimeter **5256** of the retention aperture **5252** such that the fastener leg can expand the perimeter **5256** when the fastener leg is inserted therein.

In various embodiments, referring again to FIG. **165**, the aperture **5252** can be defined by the deformable members **5253**, wherein each deformable member **5253** can be configured to deflect relative to, or independently of, the other deformable members **5253**. In at least one such embodiment, adjacent deformable members **5253** can be separated by slots **5254** which can be configured to permit each deformable member **5253** to flex relative to the others. In various embodiments, the retention matrix body **5258** can comprise a flat, or at least substantially flat, sheet of material having a tissue-contacting surface **5251** and a top surface **5257**. In at least one such embodiment, the tissue-contacting surface **5251** and the top surface **5257** can be parallel, or at least substantially parallel, to one another. In various embodiments, each deformable member **5253** can comprise a first portion **5253a** and a second portion **5253b**, wherein the first portion **5253a** can extend in a first direction and the second portion **5253b** can extend in a different, or second, direction. In at least one such embodiment, the retention matrix body **5258** can define a plane and the first portions **5253a** of the deformable members **5253** can lie within such a plane. In various embodiments, the second portions **5253b** of the deformable members

5253 can extend at an angle relative to the first portions **5253a**. In at least one such embodiment, the second portions **5253b** can extend in directions which are pointed away from the top surface **5257** of the retention matrix body **5258** and, in certain embodiments, the second portions **5253b** can converge toward the central axis **5259** of the retention aperture **5252**. In any event, in various embodiments, the second portions **5253b** can be configured to deflect away from the central axis **5259** when the fastener leg is inserted therethrough. In certain embodiments, referring again to FIG. **165**, the second portions **5253b** can be arranged circumferentially around the aperture **5252** and can define a pocket therebetween. More particularly, the second portions **5253b** can define a pocket which can be configured to receive the tip of the fastener leg when it is inserted into the retention aperture **5252**. In various embodiments, the second portions **5253b** of the deformable members **5253** can define a polygonal, or an at least substantially polygonal, pocket, for example. In various embodiments, the pocket can be defined by a suitable number of deformable members, such as four deformable members **5253** (FIG. **165**) which can define a square, six deformable members **5253** (FIG. **166**) which can define a hexagon, or eight deformable members **5253** (FIG. **167**) which can define an octagon, for example.

In various embodiments, referring now to FIG. **168**, a retention matrix, such as retention matrix **5350**, for example, can be formed from a flat, or an at least substantially flat, sheet of material such as titanium and/or stainless steel, for example. In at least one such embodiment, a plurality of apertures **5352** can be formed in the body **5358** of the retention matrix **5350** by one or more stamping processes. The sheet of material can be positioned in a stamping die which, when actuated, can punch out certain portions of the material in order to form slots **5354**, apertures **5355** of slots **5354**, and/or the perimeter **5356** of the retention aperture **5352**, for example. The stamping die can also be configured to bend the deformable members **5353** in a suitable configuration. In at least one such embodiment, the stamping die can deform the second portions **5353b** upwardly relative to the first portions **5353a** along a crease line **5353c**. In various embodiments, referring now to FIG. **169**, a retention matrix, such as retention matrix **5450**, for example, can comprise a plurality of retention apertures **5452**. Similar to the above, the perimeter **5456** of each retention aperture **5452** can be defined by a plurality of deformable members **5453** separated by slots, or slits, **5454**. In at least one such embodiment, the entirety of each deformable member **5453** can be bent upwardly wherein the free ends of the cantilevers comprising the deformable members **5453** can define the perimeter **5456**. In various embodiments, the retention matrix **5450** can comprise a plurality of apertures **5455** surrounding, or at least substantially surrounding, the retention aperture **5452**. In at least one such embodiment, the apertures **5455** can be arranged in a circular array surrounding or enclosing a perimeter defined by the fixed ends of the cantilevers of the deformable members **5453**. In certain embodiments, each aperture **5455** can comprise a circular, or at least substantially circular, perimeter and/or any other suitable perimeter. In use, the apertures **5455** can provide, one, strain relief to the bases of the deformable members **5453** attached to the retention matrix body **5458** and, two, means for increasing the flexibility of the deformable members **5453**. In various embodiments, larger apertures **5455** can provide more flexibility to the deformable members **5453** as compared to smaller apertures **5455**. Furthermore, apertures **5455** which are closer to the deformable members **5453** can provide more flexibility as compared to apertures **5455** which are further away.

In various embodiments, referring now to FIG. 170, a retention matrix, such as retention matrix 5550, for example, can comprise a plurality of retention apertures 5552. Each retention aperture 5552 can comprise an elongate slot 5554 having enlarged circular, or at least substantially circular, ends 5555. In at least one such embodiment, the ends 5555 can be defined by a diameter which is wider than the slot 5554. In certain embodiments, the elongate slot 5554 and the ends 5555 can be positioned along, and/or centered along, a longitudinal axis 5559. In various embodiments, the slot 5554 and the ends 5555 can define two opposing tabs 5553 which can be configured to engage a leg of a fastener and deflect as the fastener leg is inserted therethrough. In at least one embodiment, ends 5555 having a larger perimeter, or diameter, can define longer tabs 5553 which can be more flexible than tabs 5553 defined by ends 5555 having a smaller perimeter, or diameter. In various embodiments, the ends 5555 can have the same perimeter and diameter and, in at least one such embodiment, each tab 5553 can be symmetrical about an axis which is perpendicular, or at least substantially perpendicular, to the longitudinal axis 5559. Alternatively, the ends 5555 can have different perimeters and/or diameters wherein, in at least one embodiment, each tab 5553 may not be symmetrical about its axis. In at least one such alternative embodiment, the tabs 5553 may twist about their axes as the fastener leg is inserted through the retention aperture 5552. In various embodiments, referring now to FIG. 171, a retention matrix, such as retention matrix 5650, for example, can comprise a plurality of retention apertures 5652. Each retention aperture 5652 can comprise an elongate slot 5654 comprising circular, or at least substantially circular, ends 5655. In at least one such embodiment, the elongate slot 5654 and the ends 5655 can be positioned along, and/or centered along, a longitudinal axis 5659. In various embodiments, each end 5655 can be defined by a diameter which is the same as, or at least substantially the same as, the width of the slot 5654.

In various embodiments, referring now to FIG. 172, a retention matrix, such as retention matrix 5750, for example, can comprise a plurality of retention apertures 5752. Each retention aperture 5752 can comprise a plurality of slots, such as slots 5754, for example, having enlarged ends 5755. In at least one such embodiment, the slots 5754 and the ends 5755 can be positioned along and/or centered along longitudinal axes 5759. In various embodiments, the axes 5759 can extend in directions which are perpendicular or transverse to one another. In certain embodiments, the slots 5754 and the ends 5755 can define four tabs 5753, for example, which can be configured to engage a fastener leg and deflect when the fastener leg is inserted through the retention aperture 5752. In at least one embodiment, each tab 5753 can comprise a triangular, or at least substantially triangular, configuration, such as an equilateral triangle, for example. In various other embodiments, referring now to FIG. 173, a retention matrix, such as retention matrix 5850, for example, can comprise a plurality of retention apertures 5852. Each retention aperture 5852 can comprise a plurality of slots, such as slots 5854, for example, having ends 5855, wherein the slots 5854 and the ends 5855 can be positioned along and/or centered along longitudinal axes 5859. In various embodiments, the axes 5859 can extend in directions which are perpendicular or transverse to one another. In certain embodiments, the slots 5854 and the ends 5855 can define tabs 5853 which can be configured to engage a fastener leg and deflect when the fastener leg is inserted through the retention aperture 5852. In at least one embodiment, each tab 5853 can comprise an arcuate profile. More particularly, each tab 5853 can com-

prise a curved end, as opposed to a pointed end depicted in FIG. 170, which can be configured to contact the fastener leg.

In various embodiments, referring now to FIG. 174, a retention matrix, such as retention matrix 5950, for example, can comprise a plurality of retention apertures 5952. Each retention aperture 5952 can comprise a plurality of slots, such as slots 5954, for example, wherein each slot 5954 can extend along, and/or can be centered along, an axis 5959. In various embodiments, the axes 5959 can be transverse to each other and, in at least one such embodiment, the axes 5959 can be arranged such that all of the axes 5959 extend through a center of the retention aperture 5952 and are spaced equidistantly, or at least substantially equidistantly, from each other. In at least one embodiment, each slot 5954 can comprise an open end facing the center of the retention aperture 5952 and a second, or closed, end 5955 at the opposite end of the slot 5954. Similar to the above, the slots 5954 and the ends 5955 can define three tabs 5953, for example, which can be configured to engage a fastener leg and deflect when the fastener leg is inserted into the retention aperture 5952. In various embodiments, each tab 5953 can comprise an arcuate configuration extending between adjacent ends 5955 of the slots 5954. In various embodiments, referring now to FIG. 175, a retention matrix, such as retention matrix 6050, for example, can comprise a plurality of retention apertures 6052. Each retention aperture 6052 can comprise a tab 6053 which can be configured to engage a fastener leg and to deflect when the fastener leg is inserted into the retention aperture 6052. In at least one such embodiment, the tab 6053 can comprise a base fixed to the retention matrix body 6058 and a free end comprising an arcuate or curved profile 6056 which can be configured to contact the fastener leg. In certain embodiments, the fastener leg can be a staple leg comprised of a round wire wherein the curved profile 6056 can be configured to match, or at least substantially match, a curved outer surface of the round wire.

In various embodiments, referring again to FIG. 175, the retention matrix body 6058 can comprise a plurality of slots 6054 and apertures 6055 which can be configured to define the tab 6053 and various portions of the retention aperture 6052. In at least one embodiment, the tab 6053 can comprise a rectangular configuration comprising parallel, or at least substantially parallel, sides. In certain embodiments, referring now to FIG. 176, a retention matrix, such as retention matrix 6150, for example, can comprise a plurality of retention apertures 6152. Each retention aperture 6152 can comprise a tab 6153 which can be configured to engage a fastener leg and to deflect when the fastener leg is inserted into the retention aperture 6152. In at least one such embodiment, the tab 6153 can comprise a base fixed to the retention matrix body 6158 and a free end comprising an arcuate or curved profile 6156 which can be configured to contact the fastener leg. In various embodiments, the retention matrix body 6158 can comprise a plurality of slots 6154 and apertures 6155 which can be configured to define the tab 6153 and various portions of the retention aperture 6152. In at least one embodiment, the tab 6153 can comprise a tapered configuration comprising arcuate sides. In at least one such embodiment, the tab 6153 can taper geometrically with the base being wider than the free end, for example.

In various embodiments, as described above, a fastening system can comprise a plurality of staples comprising staple legs which are inserted through a plurality of retention apertures in a retention matrix. In certain embodiments, as described in greater detail below, the staples can be held in a first jaw and the retention matrix can be held in a second jaw, wherein at least one of the first jaw and the second jaw can be moved toward the other. In various circumstances, the staples

positioned within the first jaw can be secured therein such that the staple legs are aligned with the retention apertures when the retention matrix is engaged with the staple legs. In certain embodiments, referring to FIGS. 177 and 178, a fastener system can comprise a staple cartridge 6200, for example, positioned in a first jaw of a surgical stapler and a retention matrix 6250, for example, positioned in a second jaw of the surgical stapler. Referring now to FIGS. 184 and 185, further to the above, the retention matrix 6250 can comprise a plurality of retention apertures 6252, wherein each retention aperture 6252 can comprise a perimeter 6256 defined by one or more deflectable members 6253. In at least one such embodiment, further to the above, the deflectable members 6253 defining each aperture 6252 can define a pocket 6201. In various embodiments, each pocket 6201 can comprise a curved and/or concave surface, for example, which can be configured to guide a tip of a staple leg into the aperture 6252 in the event that the staple leg is misaligned with the retention aperture 6252 and initially contacts the deflectable members 6253 and/or the tissue-contacting surface 6251, for example.

In various embodiments, further to the above, the fastening system can further comprise a plurality of staples 6220 comprising staple legs 6221 which can be inserted through the retention apertures 6252 in the retention matrix 6250. In at least one such embodiment, each staple 6220 can comprise a substantially U-shaped configuration, for example, comprising a base 6222 from which the staple legs 6221 can extend upwardly. In various embodiments, referring now to FIGS. 180 and 181, the retention apertures 6252 in the retention matrix 6250 can be arranged in two parallel, or at least substantially parallel, longitudinal rows, for example, which can extend along, or parallel to, a longitudinal axis of the retention matrix. In certain embodiments, the retention apertures 6252 in a first row can be offset, or staggered, with respect to the retention apertures 6252 in a second row. In at least one such embodiment, each staple 6220 can comprise a first staple leg 6221 positioned in a retention aperture 6252 in the first row of and a second staple leg 6221 positioned in a retention aperture 6252 in the second row wherein, as a result, the bases 6222 can extend in a direction which is transverse to the longitudinal axis of the retention matrix 6250. In at least one such embodiment, the staples 6220 can be parallel, or at least substantially parallel, to one another. More particularly, a base 6222a of a staple 6220a can be parallel to, or at least substantially parallel to, a base 6222b of a staple 6220b which can be parallel to, or at least substantially parallel to, a base 6222c of a staple 6220c, for example. In at least one embodiment, the staple legs 6221a of staple 6220a can define a plane which is parallel to, or at least substantially parallel to, a plane defined by the staple legs 6221b of staple 6220b which can be parallel to, or at least substantially parallel to, a plane defined by the staple legs 6221c of staple 6220c, for example.

In various embodiments, referring now to FIGS. 177 and 179, the staple cartridge 6200 can comprise a plurality of staples 6220 and, in addition, an alignment matrix 6260 comprising a plurality of alignment guides, such as slots, grooves, and/or apertures, for example, which can be configured to align the staples 6220. In various circumstances, the alignment matrix 6260 can be configured such that the staple legs 6221 of the staples 6220 are aligned with the retention apertures 6252 in the retention matrix 6250 before the retention matrix 6250 is engaged with the staple legs 6221. In various embodiments, referring now to FIGS. 182 and 183, the alignment matrix 6260 can comprise a plurality of alignment apertures 6262 which can be configured to closely receive the staple legs 6221 of the staples 6220. In at least one such embodiment, each staple 6220 can comprise a base 6222 and

two staple legs 6221 extending from the base 6222 wherein the bases 6222 of the staples 6220 can extend around a bottom surface 6264 of the retention matrix 6260 and the staple legs 6221 can extend upwardly through the alignment apertures 6262. In certain embodiments, each alignment aperture 6262 can be circular, or at least substantially circular, and can be defined by a diameter which is equal to or slightly larger than the diameter of the staple leg 6221 extending therethrough. In various embodiments, the alignment matrix 6260 can further comprise a plurality of raised members 6263 which can extend upwardly from the top surface 6261 of the alignment matrix 6260 and surround, or at least partially surround, the alignment apertures 6262. In certain embodiments, the raised members 6263 can provide for longer alignment apertures 6262 wherein, in various circumstances, longer apertures 6262 can provide more control over the alignment of the staple legs 6221 than shorter apertures 6262.

In use, in various embodiments, a first jaw supporting the staple cartridge 6200 can be positioned on one side of the tissue that is to be stapled and a second jaw supporting the retention matrix 6250 can be positioned on the other side of the tissue. Once the jaws have been suitably positioned relative to the tissue, in certain embodiments, the second jaw and the retention matrix 6250 can be moved toward the staple cartridge 6200. As the staple legs 6221 are being inserted through the retention apertures 6252 of the retention matrix 6250, in various embodiments, a tissue-contacting, or bottom, surface 6251 of the retention matrix 6250 can contact the tissue and press the tissue against the tissue-contacting, or top, surface 6261 of the alignment matrix 6260. In various other embodiments, as described in greater detail further below, the staple cartridge 6200 can further comprise a compressible cartridge body positioned above the top surface 6261 of the alignment matrix 6260, for example, which can contact the tissue. In certain embodiments, referring again to FIGS. 179 and 183, the alignment matrix 6260 can further comprise one or more apertures 6203 defined therein which, when the alignment matrix 6260 is positioned against tissue, can be configured to receive a portion of the tissue therein. In embodiments where a compressible cartridge body is positioned above and/or against the alignment matrix 6260, a portion of the compressible cartridge body can enter into the apertures 6203 when the cartridge body is compressed. Similarly, the retention matrix 6250 can comprise a plurality of apertures 6202 which can be configured to receive at least a portion of the tissue therein when the retention matrix 6250 is positioned against the tissue.

As the staple legs 6221 of the staples 6220 are inserted through the retention apertures 6252 of the retention matrix 6250, further to the above, the tips of the staple legs 6221 may protrude upwardly from the top surface 6257 of the retention matrix 6250. In various circumstances, as described above, the tips of the staple legs 6221 may remain unbent after they have been inserted through the retention apertures 6252. In certain embodiments, referring now to FIGS. 186-189, a fastening system comprising the staple cartridge 6200 and the retention matrix 6250 may further comprise a plurality of protective caps or covers, such as caps 6270, for example, which can be assembled to the staple legs 6221 protruding above the retention matrix 6250. In various embodiments, each cap 6270 can entirely, or at least partially, cover the sharp end of a staple leg 6221 such that the sharp end does not contact tissue positioned adjacent thereto. In at least one embodiment, referring now to FIG. 189, each cap 6270 can comprise an aperture 6271 defined therein which can be configured to closely receive a tip of a staple leg 6221 therein. In various embodiments, the caps 6270 can be comprised of an

103

elastomeric material, such as silicone, polyisoprene, sanoprene, and/or natural rubber, for example. In at least one embodiment, the aperture 6271 can comprise a perimeter or diameter which is smaller than the perimeter or diameter of the staple leg 6221 inserted therein. In at least one such embodiment, the aperture 6271 in the protective cap 6270 can expand in order to receive the staple leg 6221 therein. In various alternative embodiments, the caps 6270 may not comprise apertures and the tips of the staple legs 6221 can be configured to incise the caps 6270 as the legs 6221 are inserted therein. In any event, in various embodiments, each cap 6270 can be seated onto a staple leg 6221 until the base 6272 of the cap 6270 abuts, or is positioned adjacent to, the top surface 6257 of the retention matrix 6250. In various circumstances, the caps 6270 can be configured such that they are seated snugly onto the tips of the staple legs 6221 such that they are not easily removed therefrom. In certain embodiments, each cap 6270 can comprise a conical, or at least substantially conical, outer surface, for example. In various embodiments, the caps 6270 can comprise any suitable shape, such as shapes comprising a parabolic, or at least substantially parabolic, outer surface, for example.

In various embodiments, the fastener system described above, for example, could be deployed using the surgical stapler depicted in FIGS. 190-192, for example. In various embodiments, the end effector can comprise a first jaw, or staple cartridge channel, 6230 which can be configured to support the staple cartridge 6200 therein and a second jaw 6240 which can be configured to support the retention matrix 6250 and the plurality of protective caps 6270. Referring primarily to FIG. 190, which illustrates the second jaw 6240 in an open configuration, the jaws 6230 and 6240 can be positioned relative to tissue T such that the tissue T is positioned intermediate the retention matrix 6250 and the staple cartridge 6200. In various embodiments, as discussed above, the staple cartridge 6200 can further comprise a compressible cartridge body, such as cartridge body 6210, for example, in which the staples 6220 and the alignment matrix 6260 can be positioned. In at least one such embodiment, the tissue T can be positioned against a top surface of the cartridge body 6210. In certain embodiments, the second jaw 6240 can comprise a plurality of recesses, or apertures, 6245 configured to receive the plurality of protective caps 6270 and, in addition, one or more retention features, or retainers, which can be configured to hold the retention matrix 6250 in position over the caps 6270. In at least one such embodiment, the retention matrix 6250 can be configured to retain the caps 6270 in the apertures 6245. In various embodiments, referring now to FIG. 202, each aperture 6245 can be configured to receive a portion of, or the entirety of, a cap 6270 therein. In certain embodiments, the apertures 6245 can be sufficiently sized and configured such that the caps 6270 can be secured therein by at least one of a press-fit and/or snap fit arrangement, for example. In some embodiments, at least one adhesive could be utilized to secure the caps 6270 in the apertures 6245. In at least one such embodiment, such an adhesive could be selected such that caps 6270 can detach from the second jaw 6240 after the caps 6270 have been engaged with the staple legs 6221 and the second jaw 6240 is moved away from the implanted fastener assembly. In certain embodiments, referring now to FIG. 203, the second jaw 6240 can further comprise at least one cover sheet 6246 which can be assembled to the second jaw 6240 and can extend over and retain the caps 6270 in the apertures 6245. In at least one such embodiment, at least a portion of the cover sheet 6246 can be secured to the jaw 6240 utilizing at least one adhesive, for example. In use, in at least one embodiment, the cover sheet 6246 can be at least partially detached

104

from the jaw 6240 before the end effector is inserted into a surgical site. In certain embodiments, the cover sheet 6246 can be comprised of an implantable material, such as PDS and/or PGA, for example, which can be incised by the staple legs 6221 as the staple legs 6221 emerge from the retention matrix 6250. In at least one such embodiment, the cover sheet 6246 can be secured in the fastening system intermediate the covers 6270 and the retention matrix 6250.

Further to the above, referring now to FIG. 191, the jaw 6240 can be moved from an open position to a closed position in which the tissue T is positioned against the retention matrix 6250 and the cartridge body 6210. In such a position, the retention matrix 6250 may not yet be engaged with the staples 6220. In various embodiments, the jaw 6240 can be moved between its open position and its closed position by an actuator 6235. In at least one such embodiment, the jaw 6240 can comprise a distal pin 6243 and a proximal pin 6244 extending therefrom, wherein the distal pin 6243 can slide vertically, or at least substantially vertically, within a distal slot 6233 defined in the cartridge channel 6230, and wherein the proximal pin 6244 can slide vertically, or at least substantially vertically, within a proximal slot 6234 which is also defined in the staple cartridge channel 6230. In use, the actuator 6235 can be retracted proximally in order to drive the pins 6243 and 6244 into the upper ends of their respective slots 6233 and 6234 as illustrated in FIG. 191. In at least one such embodiment, the actuator 6235 can comprise a distal drive slot 6236 and a proximal drive slot 6237, wherein the sidewalls of the drive slots 6236 and 6237 can be configured to contact the distal pin 6243 and the proximal pin 6244, respectively, and drive the pins 6243 and 6244 upwardly as the actuator 6235 is moved proximally. More particularly, as the actuator 6235 is moved proximally, the distal pin 6243 can slide up an inclined first portion 6236a of the distal drive slot 6236 into an intermediate, or second, portion 6236b and, similarly, the proximal pin 6244 can slide up an inclined first portion 6237a of the distal drive slot 6237 into an intermediate, or second, portion 6237b. As the pins 6243 and 6244 are both moved upwardly, the jaw 6240 can be rotated downwardly toward the tissue T into a closed position.

Further to the above, referring now to FIG. 192, the actuator 6235 can be pulled further proximally in order to push the second jaw 6240 downwardly toward the first jaw 6230, compress the cartridge body 6210, and engage the retention matrix 6250 and the plurality of protective caps 6270 with the staple legs of the staples 6220. In at least one such embodiment, the additional proximal movement of the actuator 6235 can cause the sidewalls of the drive slots 6236 and 6237 to contact the pins 6243 and 6244, respectively, and drive the pins 6243 and 6244 downwardly toward the bottom ends of the slots 6233 and 6234, respectively. In such circumstances, the actuator 6235 can be pulled proximally such that, one, the distal pin 6243 exits the second portion 6236b of the drive slot 6236 and enters into an inclined third portion 6236c and, similarly, the proximal pin 6244 exits the second portion 6237b of the drive slot 6237 and enters into an inclined third portion 6237c. As the pins 6243 and 6244 are both moved downwardly, the second jaw 6240 can move downwardly toward the first jaw 6230 into a fired position. In at least one such embodiment, the second jaw 6240 can be moved downwardly such that the retention matrix 6250 remains parallel, or at least substantially parallel, to the top surface of the cartridge body 6210 and/or parallel, or at least substantially parallel, to the alignment matrix 6260. In any event, once the retention matrix 6250 and the protective caps 6270 have been engaged with the staple legs 6221 of the staples 6220, as illustrated in FIG. 194, the second jaw 6240 can be returned to

105

an open, or an at least substantially open, position. In at least one such embodiment, the actuator 6235 can be pushed distally in order to drive the pins 6243 and 6244 to the top ends of the slots 6233 and 6234, respectively, and then driven downwardly toward the bottom ends of the slots 6233 and 6234 once the pins have passed through the intermediate portions 6236b and 6237b of the respective drive slots 6236 and 6237. Once the second jaw 6240 has been opened, the first jaw 6230 can be detached from the implanted staple cartridge 6200 and the first and second jaws 6230, 6240 can be removed away from the implanted fastener assembly, as illustrated in FIG. 193.

Referring to FIG. 192 once again, the reader will note that the pins 6243 and 6244 are not illustrated as being seated in the very bottoms of their respective slots 6233 and 6234 even though the retention matrix 6250 and the caps 6270 have been engaged with the staple legs 6221. Such circumstances can arise when thick tissue T is positioned between the retention matrix 6250 and the cartridge body 6210. In circumstances where thinner tissue T is positioned between the retention matrix 6250 and the cartridge body 6210, referring now to FIG. 195, the pins 6243 and 6244 can be driven further downwardly into their respective slots 6233 and 6234 as illustrated in FIG. 197. In general, in at least one such embodiment, the actuator 6235 can be pulled proximally in order to drive the pins 6243 and 6244 upwardly and downwardly through the progressions described above and illustrated in FIGS. 195-197 and, owing to the thinner tissue T, the retention matrix 6250 and the protective caps 6270 can be driven further onto the staple legs 6221 of the staples 6220, as illustrated in FIGS. 198 and 199. In various embodiments, as a result of the adjustability afforded by the retention matrix 6250, the same, or at least substantially the same, compressive pressure can be obtained in the fastened tissue regardless of whether the tissue captured within the end effector is thick or thin. In certain embodiments, the adjustability afforded by the retention matrix 6250 can allow a surgeon can select whether to apply a larger compressive pressure or a smaller compressive pressure to the tissue by selecting the depth to which the retention matrix 6250 is seated. In at least one such embodiment, the range in which the retention matrix 6250 can be seated onto the staple legs 6221 can be determined by the lengths, or ranges, of the slots 6233 and 6234, for example.

In various embodiments, as described above, the protective caps 6270 can be comprised of a soft or flexible material, for example, which can be configured to grip the ends of the staple legs 6221. In certain embodiments, the protective caps 6270 can be comprised of a bioabsorbable plastic, polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example, and/or a bio-compatible metal, such as titanium and/or stainless steel, for example. As illustrated in FIG. 189, in at least one embodiment, each cap 6270 can be unconnected to the other caps 6270. In certain other embodiments, one or more caps 6270 can be mounted to the retention matrix 6250. In at least one such embodiment, the caps 6270 can be connected to the retention matrix 6250 by at least one adhesive, for example, wherein the apertures 6271 in the caps 6270 can be aligned, or at least substantially aligned, with the retention apertures 6252 in the retention matrix 6270. In various embodiments, referring now to FIG. 200, a protective cap, such as a cap 6370, for example, can define an inner cavity, or dome, 6374 which can be configured to receive a tip of a staple leg 6221,

106

for example, therein. In at least one such embodiment, the cap 6370 can comprise a bottom 6372 and an aperture 6371 extending through the bottom 6372. In various embodiments, the aperture 6371 can be defined by one or more deflectable members 6373 which can be configured to deflect when the staple leg 6221 is inserted therethrough. In certain embodiments, two or more caps 6370, for example, can be connected together to form an array of caps 6370. In at least one such embodiment, referring now to FIG. 201, a plurality of caps 6370 can be connected together by a sheet of material 6375. In certain embodiments, the sheet 6375 can be sufficiently rigid in order to maintain a desired arrangement and/or alignment of the caps 6370. In at least one embodiment, the caps 6370 can be comprised of a biocompatible metal, such as titanium and/or stainless steel, for example, and the sheet 6375 can be comprised of a bioabsorbable plastic, polyglycolic acid (PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. In various embodiments, a sheet 6375 can be comprised of a bioabsorbable material including an anti-microbial agent, such as colloidal silver and/or triclosan, for example, stored and/or dispersed therein which can be released as the sheet 6375 is bioabsorbed, for example.

In various embodiments, further to the above, the sheet 6375 can be injection molded around the caps 6370 utilizing an injection molding process, for example, such that the caps 6370 are embedded in the sheet 6375. In certain other embodiments, the sheet 6375 can be molded utilizing an injection molding process, for example, wherein apertures 6376 can be formed in the sheet 6375 during the injection molding process and/or after the injection molding process utilizing a stamping process, for example. In either event, the caps 6370 can be inserted into and secured in the apertures 6376 utilizing a press-fit and/or snap-fit interconnection and/or at least one adhesive. In certain embodiments, each cap 6370 can comprise an annular groove surrounding, or at least partially surrounding, the perimeter of the cap 6370 which can be configured to receive the perimeter of an aperture 6376 therein. In certain embodiments, the sheet 6375 can be comprised of a flexible and/or pliable material which can permit relative movement between the caps 6370. In at least one such embodiment, the flexible sheet 6375 can be comprised of a rubber, plastic, and/or silicone material, for example, and the caps 6370 can be comprised of a rigid material, such as metal, for example. In at least one such embodiment, similar to the above, the flexible material can be molded around the caps 6370. In certain embodiments, the caps 6370 can be pressed into a pre-molded sheet 6375, for example. In various embodiments, the durometer of the flexible material can be selected to provide a desired stiffness of the sheet 6375. In certain embodiments, the sheet 6375 can be configured such that it comprises a flexible band. In any event, the sheet 6375 can facilitate the assembly of the caps 6370 into an end effector as a plurality of the caps 6370 can be positioned and/or aligned simultaneously within the end effector. Furthermore, the sheet 6375 connecting the caps 6370, once implanted, can strengthen or bolster the tissue along the staple line, for example. In addition to or in lieu of a sheet connecting the caps 6370, the caps 6370 can be connected together by a plurality of links. In at least one such embodiment, such links can be flexible and can permit relative movement between the caps 6370.

In various embodiments, referring now to FIGS. 204 and 205, a protective cap, such as cap 6470, for example, can comprise a forming surface which can be configured to deform a tip of a staple leg. In at least one such embodiment, the cap 6470 can comprise a base 6472 which can include an aperture 6471 extending therethrough. In various embodiments, the aperture 6471 can be configured to closely receive a staple leg, such as a staple leg 6221, for example, therein. In at least one embodiment, the aperture 6471 can be defined by a diameter or perimeter which can be equal to or larger than the diameter or perimeter of the staple leg 6221. In various embodiments, the cap 6470 can further comprise a cavity, or dome, 6474 which can be configured to receive the tip of the staple leg 6221 as it is inserted into the cap 6470. Referring primarily to FIG. 205, the cap 6470 can further comprise an anvil, or forming surface, 6473 which can be configured to deflect and deform the staple leg 6221. In various circumstances, the forming surface 6473 can be curved and/or concave, for example, and can be configured to curl the staple leg 6221 as it is inserted into the cap 6470. In certain embodiments, the staple leg 6221 can be sufficiently deformed such that it cannot be withdrawn through the aperture 6471 and, as a result, the cap 6470 can become locked to the staple leg 6221. In at least one such embodiment, the base 6472 of the cap 6470 can define a lip extending around the aperture 6471 which can prevent the deformed staple leg 6221 from being removed from the cavity 6474. In various circumstances, as a result of the above, one or more caps 6470 can prevent, or inhibit, a retention matrix, such as retention matrix 6250, for example, from backing up or being disengaged from the staples 6220. In various embodiments, although not illustrated, the cap 6470 can be symmetrically, or at least substantially symmetrically, formed, and the aperture 6471 can be located along a central axis 6479 extending through the cap 6470. In various alternative embodiments, referring again to FIG. 204, the aperture 6471 can be offset with respect to the central axis 6479. In at least one such embodiment, the offset aperture 6471 can allow the staple leg 6221 to contact a side of the forming surface 6473 and curl over to the other side of the forming surface 6473 instead of contacting the center of the forming surface 6473, as may occur in embodiments comprising a centered aperture 6471 mentioned above.

In various embodiments, as discussed above, a retention matrix, such as retention matrix 6250, for example, can be comprised of a sheet of material and a plurality of retention apertures 6252 extending therethrough. In at least some embodiments, the sheet of material comprising the retention matrix 6250 can be rigid or substantially inflexible. In certain other embodiments, a retention matrix can be comprised of an array of retention matrix elements and a plurality of flexible connectors, or links, connecting the retention matrix elements. In various embodiments, referring now to FIG. 206, a retention matrix, or a portion of retention matrix, 6550 can comprise a plurality of element bodies 6505 which can be connected together by one or more connecting links 6507. In at least one embodiment, each element body 6505 can comprise a plurality of deformable members 6553 which define a retention aperture 6552 therein. In certain embodiments, the element bodies 6505 and the connecting links 6507 of a retention matrix 6550 can be integrally formed and can comprise a unitary piece of material. In various embodiments, the retention matrix 6550 can be stamped or cast, for example, from a metal material, such as titanium and/or stainless steel, for example. In at least one embodiment, the retention matrix 6550 can be comprised of plastic, such as polyetheretherketone (PEEK), polypropylene which is marketed under the trade name Prolene, polyester, polyethylene terephthalate

which is marketed under the trade names Ethibond and Mersilene, polyvinylidene fluoride, polyvinylidene fluoride-co-hexafluoropropylene, poly hexafluoropropylene-VDF which is marketed under the trade name Pronova, and/or long-chain aliphatic polymers Nylon 6 and Nylon 6,6 which are marketed under the trade names Ethilon & Nurolon, for example, and can be formed by an injection molding process, for example. In certain embodiments, the element bodies 6505 may not be integrally formed with the connecting links 6507. In various embodiments, a plurality of singular element bodies 6505 can be produced which are subsequently connected together and embedded in a retention matrix. In at least one such embodiment, the element bodies 6505 can be stamped from a metal material, such as titanium and/or stainless steel, for example, and placed in a plastic injection mold wherein a plastic material can be injected into the mold to form, one, a rim 6506 of material surrounding, or at least partially surrounding, the element bodies 6505 and, two, connecting links 6507 extending from the rims 6506. In certain other embodiments, one or more connector lattices can be formed comprising apertures defined within a plurality of rims 6506 wherein each such aperture can be configured to receive an element body 6505 therein. In at least one embodiment, each element body 6505 can comprise a circular, or at least substantially circular, outer perimeter and, similarly, each rim 6506 can define a circular, or at least substantially circular, aperture therein, wherein the diameter of the aperture can be equal to or smaller than the diameter of the element body 6505. In at least one such embodiment, the element bodies 6505 can be press-fit or embedded into the apertures in the rims 6505. In certain embodiments, the element bodies 6505 can be secured in the apertures utilizing at least one adhesive.

In various embodiments, further to the above, a retention matrix can comprise a plurality of element bodies 6505 and a plurality of connecting links 6507 which can connect the element bodies 6505 in any suitable array, such as those illustrated in FIGS. 207-210, for example. Regardless of the pattern of the array, in various embodiments, the connecting links 6507 can be configured to allow the element bodies 6505 and the retention apertures 6552 to move relative to one another. In at least one such embodiment, the lattice of element bodies 6505 and connecting links 6507 comprising the retention matrix 6550, once engaged with tissue, can be configured to stretch, twist, contract, and/or otherwise flex in order to permit at least some movement within the tissue yet, at the same time, resist larger movements thereof. In various embodiments, each connecting link 6507 can comprise a flexible member configured to stretch, twist, and/or contract in order to permit the retention matrix 6550 to flex intermediate the matrix retention elements 6505, for example. Referring again to FIG. 206, each link 6507 extending from a rim 6506 can be defined by a width which is narrower than the width of the element body 6505 and/or the rim 6506. In certain embodiments, referring to FIGS. 207-210, one or more links 6507 can comprise straight portions which extend along a line between adjacent element bodies 6506, for example. In at least one such embodiment, each link 6507 can comprise a first end attached to a first rim 6506 and a second end attached to a second rim 6506. In certain embodiments, referring once again to FIG. 206, two or more links 6507 can be connected to one another. In at least one such embodiment, two or more links 6507 can be connected at an intermediate hinge 6509, for example. In various embodiments, the hinge 6509 can comprise a reduction in cross-sectional thickness in one or more directions as compared to the cross-sectional thickness of the links 6507 which can permit the connected links 6507 to move relative to each other, for example. In

certain embodiments, the retention matrix **6550** can further comprise hinges **6508** which can connect the links **6507** to the rims **6506** and permit relative movement between the links **6507** and the rims **6506**. Similar to hinges **6509**, hinges **6508** can comprise a reduction in cross-sectional thickness in one or more directions as compared to the cross-sectional thickness of the links **6507**, for example.

In various embodiments, further to the above, the connected links **6507** can extend in different directions. In at least one such embodiment, a first link **6507** can extend in a first direction and a second link **6507** can extend in a second direction, wherein the first direction can be different than the second direction. In certain embodiments, the first link **6507** can extend along a first line and the second link **6507** can extend along a second line, wherein the first line and the second line can intersect each other at an angle, such as approximately 30 degrees, approximately 45 degrees, approximately 60 degrees, and/or approximately 90 degrees, for example. In various embodiments, the hinges **6508** and/or hinges **6509** can comprise living hinges which can permit the links **6507** to move relative to each other a number of times without breaking. In certain embodiments, the hinges **6508** and/or hinges **6509** can comprise frangible, or easily-breakable, portions which can break when flexed too far and/or flexed too many times. In at least one such embodiment, such frangible portions can permit one or more portions of the retention matrix **6550** to break away from another portion of the retention matrix **6550**. In various embodiments, the hinges **6508** and/or hinges **6509**, for example, can comprise sections of the retention matrix **6550** which are easier to incise than the other portions of the retention matrix **6550**. More particularly, an implanted retention matrix, and the tissue fastened by the implanted retention matrix, may often-times be incised by a cutting member for various reasons and, in order to facilitate such cross-cutting, the hinges **6508** and/or hinges **6509** can provide avenues, or thin sections, through which a cutting member can more easily pass through the retention matrix **6550**, for example. In various embodiments, further to the above, the connecting links **6507** can comprise one or more coined features or material upsets, for example, defined therein which can facilitate the bending, breakage, and/or incision of the connecting links **6507**.

In various embodiments, a retention matrix can comprise a plurality of retention matrix elements, such as matrix element bodies **6505**, for example, which can be embedded in a flexible sheet, or band, of material. In at least one embodiment, a flexible sheet of material can be formed from a bioabsorbable, elastomeric material, such as silicone, for example, wherein the flexible sheet can be produced with a plurality of apertures defined therein. In at least one such embodiment, a solid flexible sheet can be molded and a plurality of apertures can be punched out of the flexible sheet. In various alternative embodiments, the flexible sheet can be molded and the apertures defined therein can be formed during the molding process. In either event, the retention matrix elements **6505**, for example, can be inserted into and retained within the flexible sheet. In certain other embodiments, similar to the above, the flexible sheet can be formed around the matrix elements **6505**. In at least one embodiment, the flexible sheet can be comprised of a woven mesh, for example, and/or any other suitable material. Such a woven mesh, further to the above, may be easy to cross-cut.

In various embodiments, referring now to FIGS. **211** and **212**, a fastener system comprising a retention matrix, such as retention matrix **6250**, for example, can further comprise a cover, such as cover **6670**, for example, which can cover the tips of the staple legs **6221** when they extend above the top

surface **6257** of the retention matrix **6250**. In various embodiments, the cover **6670** can be attached to the retention matrix **6250**. In certain embodiments, the cover **6670** and/or the retention matrix **6250** can comprise retention features which can be configured to retain the cover **6670** to the retention matrix **6250**. In at least one embodiment, at least one adhesive can be utilized to adhere the cover **6670** to the retention matrix **6250**. In at least one embodiment, the cover **6670** can be comprised of a single layer, although the cover **6670** is illustrated as comprising two layers as described in greater detail further below. In various embodiments, referring primarily to FIG. **212**, the tips of the staple legs **6221** can extend through a bottom surface **6673** of the cover **6670**; however, the cover **6670** can comprise a sufficient thickness such that the staple tips do not extend through the top surface **6675** of the cover **6670**. In at least one such embodiment, as a result, the tips of the staple legs **6221** may not protrude from the cover **6670**. In various embodiments, the cover **6670** can comprise a plurality of layers. In at least one such embodiment, the cover **6670** can comprise a first layer **6671** and a second layer **6672**. In at least one embodiment, the first layer **6671** and the second layer **6672** can be attached to one another wherein, in at least one embodiment, the second layer **6672** can comprise a bottom surface **6676** which is adhered to the first layer **6671**. In various embodiments, the first layer **6671** and the second layer **6672** can comprise different thicknesses while, in certain embodiments, they can comprise the same thickness. In at least one embodiment, the first layer **6671** and the second layer **6672** can comprise substantially the same width and/or length. In alternative embodiments, the layers **6671** and **6672** can comprise different widths and/or lengths.

In various embodiments, further to the above, the first layer **6671** can be comprised of a compressible foam, mesh material, and/or hydrogel, for example, which can be incised by the staple legs **6211**. In at least one embodiment, the second layer **6672** can be comprised of a tougher material, or skin, such as PGA and/or PDS, for example, and/or any suitable buttress material. In at least one such embodiment, the staple legs **6221** can be configured to penetrate the first layer **6671**; however, in various embodiments, the staple legs **6221** may be unable to penetrate the second layer **6672**. In certain embodiments, the second layer **6672** can be comprised of a material having a sufficient resiliency and/or toughness which can permit the second layer **6672** to be contacted and displaced by the staple leg **6221** but not be incised, or only marginally incised, by the staple tip of the staple leg **6221**. Although not illustrated, a cover can comprise more than two layers wherein one or more of such layers may be penetration-resistant. In use, in at least one such embodiment, the retention matrix **6250** can be positioned against the tissue to be fastened and pushed downwardly such that the staple legs **6221** of the staples **6220** are pushed through the tissue **T** and the retention apertures **6252** in the retention matrix **6250** and enter into the first layer **6271** of the cover **6270**. In various embodiments, the tips of the staple legs **6221** may not enter, or at least substantially enter, into the second layer **6272** of the cover **6270**. After the retention matrix **6250** has been suitably positioned, the jaw **6240** can be opened and the cover **6670** and the retention matrix **6250** can detach from the jaw **6240** as illustrated in FIG. **211**. As illustrated in FIG. **211**, a jaw **6640** can be configured to hold more than one retention matrix **6250** and cover **6670**. In at least one such embodiment, the jaw **6640** can comprise two channels **6679** which each can be configured to receive a cover **6670** therein and a retention matrix **6250** positioned thereover such that the tissue-contacting surface **6251** of each retention matrix **6250** depends downwardly from the bottom of the jaw **6240**. In at least one

such embodiment, a retention matrix **6250** and a cover **6270** can be housed in the jaw **6640** on each side of a knife slot **6678**. In use, both retention matrices **6250** and covers **6670** can be deployed simultaneously and/or to the same depth with respect to opposing staple cartridges, such as cartridges **6200**, for example, positioned thereacross. Thereafter, in various embodiments, the fastened tissue can be incised along a cutting line by a cutting member that traverses the knife slot **6678** wherein the jaw **6640** can then be re-opened. In certain embodiments, the covers **6670** may not be attached to the retention matrix **6250**. In at least one such embodiment, the covers **6670** can be positioned in the channels **6679** and can be retained in the channels **6679** by the retention matrices **6250** which can be secured to the jaw **6640**. In various embodiments, the each retention matrix **6250** can be wider and/or longer than their respective covers **6670** such that the retention matrices **6250** can retain the entirety of their covers **6670** in position. In certain embodiments, each retention matrix **6250** can comprise the same width and/or length as their respective cover **6670**, for example.

In various embodiments, as described above, a fastener system can comprise a layer of material which can be attached to a retention matrix, such as retention matrix **6250**, for example. In at least one embodiment, referring now to FIG. **215**, a layer of material **6870** can be attached to the bottom surface **6251** of the retention matrix **6250**. In certain embodiments, the layer **6870** and/or the retention matrix **6250** can comprise retention features which can be configured to retain the layer **6870** to the retention matrix **6250**. In at least one embodiment, at least one adhesive can be utilized to adhere the layer **6870** to the retention matrix **6250**. In any event, the layer **6870** can comprise a bottom, or tissue-contacting, surface **6873** which can be configured to contact the tissue **T** when the retention matrix **6250** is moved downwardly toward the staples **6220** to engage the retention apertures **6252** with the staple legs **6221**. In at least one such embodiment, the layer **6870** can be comprised of a compressible material, such as a bioabsorbable foam, for example, which can be compressed between the bottom surface **6251** of the retention matrix **6250** and the tissue **T**. In various embodiments, the layer **6870** can further comprise at least one medicament stored and/or absorbed therein which can be expressed from the layer **6870** as the layer **6870** is compressed. In at least one embodiment, the medicament can comprise at least one tissue sealant, hemostatic agent, and/or anti-microbial material, such as ionized silver and/or triclosan, for example. In various embodiments, the compression of the layer **6870** can squeeze the medicament from the layer **6870** such that the entirety of, or at least a significant portion of, the surface of the tissue **T** is covered with the medicament. Furthermore, as the layer **6870** is compressed and the staple legs **6221** penetrate the tissue **T** and the layer **6870**, the medicament can flow down the staple legs **6221** and treat the tissue that has just been incised by the staple legs **6221**, for example. In various embodiments, the body of the retention matrix **6250** can comprise a first layer which is comprised of a biocompatible material, such as titanium and/or stainless steel, for example, and the bottom layer **6870** can comprise a second layer comprised of a bioabsorbable material, such as oxidized regenerated cellulose (ORC), biologically active agents like fibrin and/or thrombin (either in their liquid state or freeze dried), glycerin, absorbable porcine gelatin in either flue or foam configurations, and/or anti-microbials, such as ionized silver and/or triclosan, for example. Additional bioabsorbable materials can comprise Surgicel Nu-Knit, Surgicel Fibrillar, collagen/ORC which is a hybrid with a built in collagen matrix and is marketed under the trade name Promogran, polyglycolic acid

(PGA) which is marketed under the trade name Vicryl, polylactic acid (PLA or PLLA), polydioxanone (PDS), polyhydroxyalkanoate (PHA), poliglecaprone 25 (PGCL) which is marketed under the trade name Monocryl, polycaprolactone (PCL), and/or a composite of PGA, PLA, PDS, PHA, PGCL and/or PCL, for example. Although only one layer **6870** is illustrated in FIG. **215**, any suitable number of layers could be used. In at least one embodiment, a first layer comprising a first medicament could be attached to the retention matrix **6250** and a second layer comprising a second, or different, medicament could be attached to the first layer. In at least one such embodiment, a plurality of layers could be used wherein each layer can comprise a different medicament and/or a different combination of medicaments contained therein.

In various embodiments, referring now to FIG. **213**, a fastener system can comprise a layer of material **6770** attached to the bottom surface **6251** of the retention matrix **6250**. In certain embodiments, the layer **6770** and/or the retention matrix **6250** can comprise retention features which can be configured to retain the layer **6770** to the retention matrix **6250**. In at least one embodiment, at least one adhesive can be utilized to adhere the layer **6770** to the retention matrix **6250**. In any event, the layer **6770** can comprise a bottom, or tissue-contacting, surface **6773** which can be configured to contact the tissue **T** when the retention matrix **6250** is moved downwardly toward the staples **6220** to engage the retention apertures **6252** with the staple legs **6221**. In at least one such embodiment, the layer **6770** can be comprised of a compressible material, such as a bioabsorbable foam, for example, which can be compressed between the surface **6251** of the retention matrix **6250** and the tissue **T**. In various embodiments, the layer **6770** can further comprise one or more encapsulations, or cells, **6774** which can be configured to store at least one medicament therein. In certain embodiments, referring to FIG. **214**, the encapsulations **6774** can be aligned, or at least substantially aligned, with the retention apertures **6252** such that, when the staple legs **6221** are pushed through the tissue **T** and the layer **6770**, the staple legs **6221** can puncture and/or otherwise rupture the encapsulations **6774**. After the encapsulations **6774** have been ruptured, the at least one medicament **M** stored in the encapsulations **6774** can flow out onto the tissue **T**. In at least one such embodiment, the medicament **M** can comprise a fluid which can flow or wick down the staple legs **6221** and treat the tissue **T** that was just incised by the staple legs. As a result of the above, the medicament stored within the encapsulations **6774** can provide a localized treatment to the tissue. In certain embodiments, the encapsulations **6774** in the sheet **6770** can comprise different medicaments stored therein. For example, a first group of encapsulations **6774** can comprise a first medicament, or a first combination of medicaments, stored therein and a second group of encapsulations can comprise a different medicament, or a different combination of medicaments, stored therein. In various embodiments, the layer **6770** can be comprised of a flexible silicone sheet and the encapsulations **6774** can represent voids in the silicone sheet. In at least one such embodiment, the silicone sheet can comprise two layers that can be attached to one another wherein the encapsulations **6774** can be defined between the two layers. In various embodiments, the layer **6770** can comprise one or more thin sections or weakened portions, such as partial perforations, for example, which can facilitate the incision of the layer **6770** and the rupture of the encapsulations **6774** by the legs **6221**. In certain embodiments, at least a portion of the encapsulations **6774** can be positioned within domes **6777**, wherein the domes **6777** can extend upwardly from the sheet **6770**. In at least one such embodiment, the domes **6777**

113

and/or at least a portion of the encapsulations **6774** can be positioned within the pockets **6201** formed within the retention matrix **6250**. In certain embodiments, the encapsulations **6774** may comprise discrete cells which are unconnected to each other. In certain other embodiments, one or more of the encapsulations **6774** can be in fluid communication with each other via one or more passageways, conduits, and/or channels, for example, extending through the layer **6770**. The disclosure of U.S. Pat. No. 7,780,685, entitled ADHESIVE AND MECHANICAL FASTENER, which issued on Aug. 24, 2010, is hereby incorporated by reference in its entirety.

In various embodiments, further to the above, a staple cartridge comprising a cartridge body, staples, and/or an alignment matrix therein can be loaded into a first jaw of an end effector and, similarly, a retention matrix and/or one or more covers can be loaded into a second jaw of the end effector. In certain embodiments, referring now to FIG. **216**, an instrument, such as cartridge loader **6990**, for example, can be used to insert two or more fastener cartridges into an end effector at the same. In at least one embodiment, the cartridge loader **6990** can comprise a handle **6991** and a cartridge carrier **6992**, wherein the cartridge carrier **6992** can comprise a first retention portion configured to retain the cartridge body **6210** of the staple cartridge **6200** thereto and, in addition, a second retention portion configured to retain a cartridge body **6980** which supports, one, a plurality of protective caps **6270** therein and, two, a retention matrix **6250** along the bottom surface thereof, for example. In various embodiments, the first and second retention portions can each comprise one or more retention members configured to releasably engage the cartridge bodies **6210** and **6980**. In use, referring now to FIGS. **217** and **218**, an end effector can comprise a first, or bottom, jaw **6230** and a second, or top, jaw **6940**, wherein the staple cartridge **6200** can be loaded into the first jaw **6230** and the cartridge body **6980** can be loaded into the second jaw **6940**. In various circumstances, the top jaw **6940** can be rotated from an open position (FIG. **217**) to a closed position (FIG. **218**) by an actuator **6235**, wherein the operation of the actuator **6235** is described above and is not repeated herein for the sake of brevity. Once the top jaw **6940** is in its closed position, referring now to FIG. **218**, the distal end **6993** of the cartridge carrier **6992** can be inserted into the end effector such that the staple cartridge **6200** is slid through the distal end **6938** of the first jaw **6930** and into a first attachment portion, or channel, **6939** in the first jaw **6230**. Similarly, the distal end **6993** of the cartridge carrier **6992** can be inserted into the end effector such that the cartridge body **6980** is slid through the distal end **6948** of the second jaw **6940** and into a second attachment portion, or channel, **6949** in the second jaw **6940**. A surgeon, or other clinician, holding the handle **6991** of the cartridge loader **6990** can push the staple cartridge **6200** and the cartridge body **6980** through the channels **6939** and **6949**, respectively, until the staple cartridge **6200** and the cartridge body **6980** are fully seated therein.

As the staple cartridge **6200** and the cartridge body **6980** are being seated, the staple cartridge **6200** and the cartridge body **6980** can each engage one or more retention portions in their respective jaws **6230** and **6940**, as described in greater detail further below. In any event, once the staple cartridge **6200** and the cartridge body **6980** have been seated, referring now to FIG. **219**, the cartridge loader **6990** can be detached from the staple cartridge **6200** and the cartridge body **6980** and removed from the end effector. In at least one such embodiment, the retention force holding the staple cartridge **6200** in the first jaw **6230** can be greater than the retention force holding the staple cartridge **6200** to the cartridge carrier **6992** such that, as the cartridge carrier **6992** is pulled distally

114

out of the end effector, the staple cartridge **6200** can remain behind in the first jaw **6230**. Similarly, the retention force holding the cartridge body **6980** in the second jaw **6940** can be greater than the retention force holding the cartridge body **6940** to the cartridge carrier **6992** such that, as the cartridge carrier **6992** is pulled distally out of the end effector, the cartridge body **6940** can remain behind in the second jaw **6940**. Once the cartridge loader **6990** has been removed from the end effector, the loaded first jaw **6230** and the loaded second jaw **6940** can be positioned relative to the tissue **T** that is to be stapled. Referring now to FIG. **220**, the second jaw **6940** can be moved from an open position (FIG. **219**) to a fired position (FIG. **220**) in order to engage the retention matrix **6250** and the plurality of protective caps **6270** carried by the cartridge body **6980** with the staples **6220** positioned within the staple cartridge **6200**.

Referring now to FIGS. **221** and **222**, the second jaw **6940** can be re-opened and the plurality of protective caps **6270** and the retention matrix **6250** can detach from the cartridge body **6980** such that the caps **6270** and the retention matrix **6250** can remain engaged with the tissue **T** and the staple cartridge **6200**. In at least one embodiment, the cartridge body **6980** can comprise a plurality of pockets in which the plurality of caps **6270** can be removably positioned and one or more retention slots configured to removably retain the retention matrix **6250** thereto. In various embodiments, the retention members of the second jaw **6940** engaged with the cartridge body **6980** can retain the cartridge body **6980** in the second jaw **6940** after the second jaw **6940** has been opened. In certain embodiments, the cartridge body **6980** can be configured to tear as the second jaw **6940** is opened such that a portion of the cartridge body **6980** is implanted with the caps **6270** and the retention matrix **6250** and a portion of the cartridge body **6980** remains in the second jaw **6940**. Similarly, referring again to FIGS. **221** and **222**, the retention members of the first jaw **6230** engaged with the cartridge body **6210** can retain the cartridge body **6210** in the first jaw **6230** after the second jaw **6940** has been opened. In certain embodiments, the cartridge body **6210** can be configured to tear as the first jaw **6230** is pulled away from the implanted cartridge **6200** such that a portion of the cartridge body **6210** is implanted with the staples **6220** and alignment matrix **6260** and a portion of the cartridge body **6210** remains in the first jaw **6230**. In various embodiments, referring now to FIGS. **223-225**, a staple cartridge, such as staple cartridge **6900**, for example, can comprise one or more longitudinal retention slots **6913** extending along the length of the cartridge body **6910** which, when the staple cartridge **6900** is inserted into a jaw **6930**, for example, can be configured to receive one or more longitudinal retention rails **6916** extending from the jaw **6930** therein. In use, in at least one embodiment, an end of the retention slots **6913** can be aligned with the distal ends of the retention rails **6916** before the staple cartridge **6900** is slid through the distal end **6938** of the retention channel **6939**, for example.

In various embodiments, referring again to FIG. **225**, the jaw **6940** can comprise two retention channels **6949**, wherein each retention channel **6949** can be configured to receive a cartridge body **6980** comprising a plurality of caps **6270** and a retention matrix **6250** therein. In certain embodiments, each cartridge body **6980** can comprise one or more longitudinal retention shoulders **6917** which can be configured to be slid along one or more longitudinal retention rails **6918** of the second jaw **6940** as the cartridge bodies **6980** are inserted into their respective retention channels **6949** in jaw **6940**. In various embodiments, the retention rails **6918** and the retention shoulders **6917** can co-operate to retain the cartridge body **6980** in the second jaw **6940** as the cartridge bodies **6980** are

115

detached from the caps **6270** and the retention matrix **6250** stored therein. In various embodiments, referring now to FIG. **224**, the second jaw **6940** can further comprise one or more distal bumps, or retention members, **6915** extending therefrom which can be configured to removably lock the cartridge bodies **6980** in their respective retention channels. In at least one such embodiment, the second jaw **6940** can comprise a distal bump **6915** configured and positioned relative to each retention channel **6949** such that each cartridge body **6980** can flex around the bumps **6915** as the cartridge bodies **6980** are being inserted into the channels **6949** wherein, just as the cartridge bodies **6915** are being fully seated in the channels **6949**, the distal ends of the cartridge bodies **6980** can clear and snap over the bumps **6915**. In order to remove the cartridge bodies **6980** after they have been expended, as described above, the cartridge bodies **6980** can be pulled back over the bumps **6915** and removed from the retention channels **6949**. Similar to the above, the first jaw **6930** can comprise one or more distal retention bumps **6914** extending therefrom which can be configured to be received in one or more retention grooves, or slots, **6912** (FIG. **223**) in the cartridge body **6910** when the staple cartridge **6900** has been fully seated.

In various embodiments, further to the above, a first fastener cartridge comprising a plurality of first fasteners positioned therein can be positioned in a first jaw of a surgical fastening device and a second fastener cartridge comprising a plurality of second fasteners positioned therein can be positioned in a second jaw of the surgical fastening device. In use, the first jaw and/or the second jaw can be moved toward the other in order to engage the first fasteners with the second fasteners and secure tissue therebetween. In certain embodiments, the first fastener cartridge and the second fastener cartridge can be engaged with each other as the first fasteners are engaged with the second fasteners. In at least one embodiment, the body of the first fastener cartridge can be comprised of a first compressible material and the body of the second fastener cartridge can be comprised of a second compressible material, wherein the first body and/or the second body can be compressed against the tissue being fastened. After the tissue has been fastened, the first jaw can be moved away from the implanted first fastener cartridge and the second jaw can be moved away from the implanted second fastener cartridge. Thereafter, the first jaw can be reloaded with another first fastener cartridge, or the like, and the second jaw can be reloaded with another second fastener cartridge, or the like, and the surgical fastening instrument can be reused. While staples can be used in some embodiments, other embodiments are envisioned comprising other types of fasteners, such as two-part fasteners which are locked together when they are engaged with one another, for example. In at least one such embodiment, the first fastener cartridge can comprise a first storage portion for storing the first fastener portions and the second fastener cartridge can comprise a second storage portion for storing the second fastener portions. In various embodiments, the fastening systems described herein can utilize fasteners comprising any suitable type of material and/or form. In certain embodiments, the fasteners can comprise penetrating members. Such penetrating members could be comprised of a polymer, a composite, and/or a multi-layered substrate, for example. An example of a multi-layered substrate could be a wire or a sheet substrate with an elastomeric or polymeric coating. It could be a thin sheet formed such that penetrating members are oriented perpendicular, or at least substantially perpendicular, to the connecting member. The penetrating members could comprise a rectangular profile, semi-circular profile, and/or any beam profile. In vari-

116

ous embodiments, the fasteners described herein can be manufactured utilizing any suitable process, such as a wire extruding process, for example. Another possibility is the use of microfabrication to create hollow penetrating members. These penetrating members could be fabricated from a process which is different than a wire extruded process and could use a combination of materials.

As described above, the tips of staple legs protruding through a retention matrix can be covered by one or more caps and/or covers. In certain embodiments, the tips of the staple legs can be deformed after they have been inserted through the retention matrix. In at least one embodiment, a jaw holding the retention matrix can further comprise anvil pockets positioned above and/or aligned with the retention apertures which can be configured to deform the staple legs as they protrude above the retention matrix. In various embodiments, the staple legs of each staple can be curled inwardly toward each other and/or toward the center of the staple, for example. In certain other embodiments, one or more of the staple legs of a staple can be curled outwardly away from the other staple legs and/or away from the center of the staple. In various embodiments, regardless of the direction in which the staple legs are curled, the tips of the staple legs can contact the body of the retention matrix and may not re-enter the tissue that has been fastened by the staples. In at least one embodiment, the deformation of the staple legs after they have passed through the retention matrix can lock the retention matrix in position.

In various embodiments, referring now to FIGS. **226** and **227**, a surgical stapling instrument, such as surgical stapler **7000**, for example, can comprise a first jaw **7030** and a second jaw **7040**, wherein the second jaw **7040** can be moved toward and away from the first jaw **7030** by the movement of actuator **6235**. The operation of actuator **6235** is described above and is not repeated herein for the sake of brevity. In various embodiments, the first jaw **7030** can comprise a distal end **7031** and a proximal end **7032**, wherein the first jaw **7030** can define a channel extending between the distal end **7031** and the proximal end **7032** which is configured to receive a staple cartridge. For the purposes of illustration, the cartridge body of such a staple cartridge is not depicted in FIG. **226**, although such a staple cartridge can comprise a cartridge body, staples **6220** positioned within the cartridge body, and staple drivers **7012** positioned underneath the staples **6220**. In certain embodiments, although not illustrated in FIG. **226** for the sake of clarity, the second jaw **7040** can be configured to hold a retention matrix, such as retention matrix **6250**, for example, over the staples **6220** and/or move the retention matrix into engagement with the legs of the staples **6220** as described above. In at least one embodiment, the surgical stapler **7000** can further comprise a sled **7010** positioned in the first jaw **7030** which can be slid from the distal end **7031** of the first jaw **7030** toward the proximal end **7032**, for example, and lift the staple drivers **7012**, and the staple **6220** supported thereon, toward the retention matrix and the second jaw **7040**. In various other embodiments, the sled **7010** can be moved from the proximal end **7032** toward the distal end **7031** in order to deploy the staples **6020**, for example. In at least one embodiment, the sled **7010** can comprise one or more inclined ramps, or cams, **7011** which can be configured to slide underneath the staple drivers **7012** and lift the staple drivers **7012** upwardly. In various embodiments, the surgical stapler **7000** can further comprise a pull, or push, rod operably coupled to the sled **7010** which can be moved proximally and/or distally by an actuator located on a handle and/or shaft of the surgical stapler **7000**, for example.

In various embodiments, referring again to FIG. **226**, the second jaw **7040** of the surgical stapler **7000** can comprise a

frame 7041, a distal end 7048, and a proximal end 7049 positioned opposite the distal end 7048. In certain embodiments, the second jaw 7040 can further comprise a guide system comprising one or more guide rails, such as guide rails 7045 and 7046, for example, extending along the longitudinal axis of the frame 7041 which, as described in greater detail further below, can be configured to guide one or more anvils, or cams, which can engage and deform the staple legs of the staples 6220 after the staple legs 6221 of the staples 6220 have passed through the retention matrix. In at least one such embodiment, the guide rails 7045 and 7046 can comprise a guide wire or cable which extends along a top portion or surface of the frame 7041, around a distal post 7047, and back along the top portion or surface of the frame 7041, for example. In various embodiments, as mentioned above and referring primarily now to FIGS. 228 and 230, the second jaw 7040 can further comprise one or more anvils, or cams, such as first anvil 7050 and second anvil 7060, for example, which can be moved longitudinally along the second jaw 7040 in order to deform the legs of the staples 6220 after they have passed through the retention matrix. In at least one embodiment, the surgical stapler 7000 can further comprise a first anvil driver, or actuator, 7051 connected to and/or operably coupled to the first anvil 7050 which can be configured to pull the first anvil 7050 proximally and/or push the first anvil 7050 distally. Similarly, in at least one embodiment, the surgical stapler 7000 can further comprise a second anvil driver, or actuator, connected to and/or operably coupled to the second anvil 7060 which can be configured to push the second anvil 7060 distally and/or pull the second anvil 7060 proximally. In various embodiments, the first anvil 7050 can comprise guide slots 7052 and the second anvil 7060 can comprise guide slots 7062 which can each be configured to slidably receive guide rail 7045 or guide rail 7046 therein. In at least one such embodiment, the guide rails 7045 and 7046 can be closely received within the guide slots 7052 and 7062 such that relative lateral, or side-to-side, movement therebetween can be prevented, or at least limited.

In certain embodiments, further to the above, the first anvil 7050 can be pulled proximally and the second anvil 7060 can be pulled distally. In at least one embodiment, referring to FIG. 226, the guide rails 7045 and 7046 and the distal post 7047 can comprise a pulley system configured to pull the second anvil 7060 distally and/or pull the second anvil 7060 proximally. In at least one such embodiment, the guide rail 7045 and the guide rail 7046 can comprise a continuous wire or cable extending around the distal post 7047, wherein a portion of the continuous wire can be pulled in order to cycle the wire around the distal post 7047. In various embodiments, the guide rail 7046, for example, can be mounted to the second anvil 7060 such that, when the continuous cable is cycled in a first direction, the second anvil 7060 can be pulled distally toward the distal end 7048 of the jaw 7040 and, when the continuous cable is cycled in a second, or opposite, direction, the second anvil 7060 can be pulled proximally toward the proximal end 7049. In at least one embodiment, referring now to FIG. 228, the guide rail 7046 can be secured within a guide slot 7062 such that a pulling force can be transmitted therebetween. In at least one such embodiment, the guide rail 7045 can be configured to slide within the other guide slot 7062. In various embodiments, the first anvil 7050 may operate independently of the second anvil 7060 and the pulley system and the guide slots 7052 defined in the first anvil 7050 may be configured to slidably receive the guide rails 7045 and 7046 such that relative movement is permitted therebetween. In various embodiments, the continuous cable comprising guide rails 7045 and 7046 can be sufficiently flexible in order

to accommodate the opening and closing of the top jaw 7040. The continuous cable can also be sufficiently flexible in order to accommodate the vertical movement of the second anvil 7060 toward and away from the bottom jaw 7030, which is described in greater detail further below.

In various embodiments, referring again to FIGS. 228 and 230, the first anvil 7050 can comprise cam followers 7055 extending therefrom which can be configured to ride in one or more cam slots, or guide slots, such as cam slot 7070 (FIG. 231), for example, defined in the frame 7041 of the second jaw 7040. More particularly, in at least one embodiment, the frame 7041 can comprise a first cam slot 7070 extending longitudinally along a first side of the frame 7041 and a second cam 7070 extending longitudinally along a second, or opposite, side of the frame 7041, wherein the cam followers 7055 extending from a first side of the first anvil 7050 can ride in the first cam slot 7070 and the cam followers 7055 extending from a second side of the first anvil 7050 can ride in the second cam slot 7070. In at least one such embodiment, the contours of each cam slot 7070 can be identical, or at least substantially identical, and can be aligned, or at least substantially aligned, with one another. Similarly, in various embodiments, the second anvil 7060 can comprise cam followers 7065 extending therefrom which can be configured to ride in the cam slots 7070 (FIG. 231) defined in the frame 7041 of the second jaw 7040. More particularly, in at least one embodiment, the cam followers 7065 extending from a first side of the second anvil 7060 can ride in the first cam slot 7070 and the cam followers 7065 extending from a second side of the second anvil 7060 can ride in the second cam slot 7070. In use, the cam followers 7055 of the first anvil 7050 and the cam followers 7065 of the second anvil 7060 can slide within the cam slots 7070 such that first anvil 7050 and the second anvil 7060 follow the contours of the cam slots 7070 as the first anvil 7050 and the second anvil 7060 are pulled proximally and/or pushed distally. In various embodiments, each cam slot 7070 can comprise a plurality of dwell, or upper, portions 7071 and a plurality of driver, or lower, portions 7072 which can be configured to move the anvils 7050 and 7060 vertically, i.e., toward and away from the bottom jaw 7030, at the same time that the anvils 7050 and 7060 are being moved longitudinally, i.e., between the distal end 7048 and the proximal end 7049 of the frame 7041, as described in greater detail further below.

When the surgical stapler 7000 is in an unfired condition, referring to FIG. 231, the first anvil 7050 can be positioned at the distal end 7048 of the frame 7041 and the second anvil 7060 can be positioned at the proximal end 7049 of the frame 7041; furthermore, referring now to FIG. 232, the staples 6220 positioned in the first jaw 7030 may not yet be inserted into the tissue T and/or the retention matrix positioned thereabove when the surgical stapler 7000 is in an unfired condition. In use, referring now to FIG. 233, the staples 6220 can be driven upwardly within the staple cavities 7033 of a staple cartridge by the staple drivers 7012 and, in addition, the first anvil 7050 can be moved proximally from the distal end 7048 of the frame 7041 toward the distal end 7049 in order to engage the staple legs 6221 of the staples 6220. In at least one embodiment, the staples 6220 can be driven upwardly before the first anvil 7050 is engaged with the staple legs 6221 thereof. In various embodiments, all of the staples 6220 may be deployed upwardly by the sled 7010 before the first anvil 7050 is advanced into contact with the staple legs 6221 or, alternatively, the sled 7010 may be moved proximally at the same time that the first anvil 7050 is moved proximally, although the sled 7010 may sufficiently lead the first anvil 7050 in order to deploy the staples 6220 ahead of the first

119

anvil 7050. In various embodiments, as illustrated in FIG. 233, the cam slots 7070 can be configured and arranged such that the forming surfaces, such as forming, or camming, surfaces 7053 and 7054, for example, of the first cam 7050 can contact at least some of the staple legs 6221 when the first cam 7050 is passing through a dwell, or upper, position. In various circumstances, the cam followers 7055 of the first anvil 7050 can each be positioned in a dwell portion 7071 of the cam slots 7070 such that the forming surfaces 7053 and 7054 are in a raised position and such that the staple legs 6221 are only partially deformed when the anvil 7050 passes thereby in the dwell position. As the first cam 7050 is moved further along the cam slots 7070, as illustrated in FIG. 234, the cam followers 7055 of the first anvil 7050 can be driven into driven, or lower, portions 7072 of the cam slots 7070 such that the forming surfaces 7053 and 7054 are moved vertically downwardly toward the staple legs 6021 in order to drive the staple legs 6021 into their finally formed configurations. Thereafter, as the first anvil 7050 is progressed further along the cam slots 7070, the first anvil 7050 can be driven vertically upwardly into another set of dwell portions 7071 of the cam slots 7070. As illustrated in FIGS. 233 and 234, the reader will note that the first anvil 7050 may only engage some of the staple legs and not others. In at least one such embodiment, the first anvil 7050 can be configured to only deform a group of staple legs comprising the distal staple legs 6221 of the staples 6220, for example. In at least one such embodiment, the first anvil 7050 can be configured to deform the distal staple legs 6221 toward the center of the staples 6220. In various embodiments, each proximal staple leg 6221 can be contacted twice by the first anvil 7050, i.e., by a first forming surface 7053 and by a second forming surface 7054 aligned with the first forming surface 7053. In at least one such embodiment, the first forming surfaces 7053 can deform the distal staple legs 6221 into a partially-deformed configuration when the first anvil 7050 is in a dwell, or upper, position and the second forming surfaces 7054 can deform the distal staple legs 6221 into a fully-formed configuration when the first anvil 7050 is moved into a driven, or lower, position. In various embodiments, referring now to FIGS. 228 and 229, the first anvil 7050 can comprise a plurality of first forming surfaces 7053 and a plurality of second forming surfaces 7054 in order to deform the distal staple legs 6221 of staples 6220 when the staple legs 6221 are arranged in more than one row or line. In various embodiments, as described in greater detail further below, the proximal staple legs 6221 of the staples 6020 can be deformed by the second anvil 7060, for example.

In various embodiments, further to the above, the first anvil 7050 can be moved from the distal end 7048 of the frame 7041 to the proximal end 7049 in order to deform all of the distal staple legs 6221 of the staples 6220. As the reader will note, the first anvil 7050 can be moved up and down relative to the undeformed proximal staple legs 6221 and, in order to accommodate such relative movement, in various embodiments, the first anvil 7050 can comprise one or more clearance slots 7057 (FIG. 230) which can be configured to receive the unbent proximal staple legs 6221 as the first anvil 7050 bends the distal staple legs 6221. Similarly, referring again to FIG. 228, the second anvil 7060 can comprise a clearance slot 7067 which can be configured to accommodate the vertical movement of the first cam actuator 7051 which moves up and down as the first anvil 7050 is moved between its dwell and driven positions as described above. After all of the distal staple legs 6221 have been bent, in at least one embodiment, the second anvil 7060 can be moved from the proximal end 7049 of the frame 7041 to the distal end 7048 by the anvil actuator 7061. Similar to the above, referring now to FIG.

120

235, the cam followers 7065 of the second anvil 7060 can slide within the cam slots 7070 such that the second anvil 7060 is moved between dwell, or upper, positions and driven, or lower, positions in order to deform the proximal staple legs 6221 inwardly toward the centers of the staples 6220, for example. Similar to the above, the second anvil 7060 can comprise a plurality of first forming, or camming, surfaces 7063 and a plurality of second forming, or camming, surfaces 7064 which can each be configured to at least partially deform and/or completely deform one or more of the proximal staple legs 6021. Referring again to FIG. 229, the second anvil 7060 can comprise a plurality of first forming surface 7063 and a plurality of second forming surfaces 7064 which can be configured to deform the proximal staple legs 6221 of staples 6220 arranged in a plurality of rows, or lines, for example. As also illustrated in FIG. 229, the first forming surfaces 7063 and the second forming surfaces 7064 of the second anvil 7060 may not be aligned with the first forming surfaces 7053 and the second forming surfaces 7054 of the first anvil 7050 wherein, as a result, the proximal legs 6221 of the staples 6220 may be positioned in different rows, or lines, than the distal legs 6221 of the staples 6220. As the reader will also note, the second anvil 7060 can push the first anvil 7050 as the second anvil 7060 is moved distally. In at least one such embodiment, the second anvil 7060 can push the first anvil 7050 back into the distal end 7048 of the frame 7041 such that the first anvil 7050 can be returned to its initial, or unfired, position. After all of the proximal staple legs 6221 of the staples 6220 have been deformed, the second anvil 7060 can be retracted proximally and returned to its initial, or unfired, position. In this way, the surgical stapler 7000 can be reset such that a new staple cartridge can be positioned in the first jaw 7030 and a new retention matrix can be positioned in the second jaw 7040 in order to use the surgical stapler 7000 once again.

In various embodiments, as described above, a surgical stapler can comprise two or more anvils which can travel longitudinally in order to engage the legs of a plurality of staples in a transverse direction. In certain embodiments, a surgical stapler can comprise an anvil which is moved proximally, for example, in order to deform a first group of staple legs and distally, for example, in order to deform a second group of staple legs. In at least one such embodiment, such an anvil can comprise forming surfaces facing proximally and forming surfaces facing distally, for example.

In various embodiments, referring now to FIG. 236, an anvil, such as anvil 7140, for example, can comprise a bottom, or tissue-contacting, surface 7141 and a plurality of forming pockets 7142 defined therein. In at least one embodiment, the anvil 7140 can comprise more than one plate, such as pocket plates 7143, for example, which can be welded into a frame 7144. In at least one such embodiment, each pocket plate 7143 can be positioned in a plate channel 7145 in the frame 7144 and welded to the frame 7144 through a weld slot 7146 extending through the frame 7144 in order to form a longitudinal weld 7147. In various circumstances, the longitudinal weld 7147 can comprise a continuous weld extending along the entire length of the weld slot 7146 or a series of spaced-apart spot welds extending along the length thereof, for example. In various embodiments, each pocket plate 7143 can comprise two or more plate portions that have been welded together. In at least one such embodiment, each pocket plate 7143 can comprise a first plate portion 7143a and a second plate portion 7143b which can be welded together along a seam 7148. In various embodiments, the first plate portion 7143a and the second plate portion 7143b of each plate 7143 can be welded together before the plates 7143 are

121

welded into the plate channels **7145** in the frame **7144**. In at least one such embodiment, the first plate portion **7143a** and the second plate portion **7143b** can comprise co-operating profiles, such as the toothed profiles illustrated in FIG. **236**, for example, which can be fitted together to form a tight seam **7148**. In at least one embodiment, each plate **7143** can comprise a height of approximately 0.02", for example, which can be taller than the depth of the plate channels **7145** such that the tissue-contacting surfaces **7141** thereof extend from the frame **7044** of the anvil **7040**. In certain embodiments, referring now to FIG. **237**, the plates **7143** can be connected together by at least one weld **7149** at the distal ends of the plates **7143**, for example.

As illustrated in FIGS. **236** and **237**, each pocket plate **7143** can comprise a plurality of forming pockets **7142** defined therein. In various embodiments, the forming pockets **7142** can be formed in the plates **7143** by any suitable manufacturing process, such as a grinding process and/or electrode-burning process, for example. In at least one such embodiment, referring now to FIGS. **238** and **239**, each forming pocket **7142** can be manufactured by first forming a deep well **7150**, then forming an arcuate or curved surface **7151** surrounding the deep well **7150**, and then forming a staple leg guide groove **7152** in the curved surface **7151**, for example. In various other embodiments, these steps can be performed in any suitable order. In various embodiments, referring now to FIG. **240**, the staple forming pockets **7142** can be formed such that the inner edges **7153** of the forming pockets are separated by a consistent, or at least substantially consistent, gap **7154**. In at least one such embodiment, the gap **7154** can be approximately 0.008", for example. Furthermore, in at least one such embodiment, the forming pockets **7142** can be positioned along two or more rows, or lines, the centerlines of which can be separated by a consistent, or at least substantially consistent, spacing **7155**. In at least one such embodiment, the spacing **7155** between the centerlines can be approximately 0.035", for example. In various embodiments, referring again to FIG. **240**, each forming pocket **7142** can taper between a narrow width **7156** and a wide width **7157**. In at least one such embodiment, the narrow width **7156** can be approximately 0.045" and the wide width **7157** can be approximately 0.075", for example. In various embodiments, the plates **7143** can be comprised of the same material as the frame **7144**. In at least one such embodiment, the plates **7143** and the frame **7144** can both be comprised of stainless steel, such as a 300 series or a 400 series stainless steel, for example, and/or titanium, for example. In various other embodiments, the plates **7143** and the frame **7144** can be comprised of different materials. In at least one such embodiment, the plates **7143** can be comprised of a ceramic material, for example, and the frame **7144** can be comprised of a stainless steel and/or titanium, for example. In various circumstances, depending on the materials used, at least one brazing process could be used to secure the plates **7143** in the frame **7144** in addition to or in lieu of the welding processes described above, for example.

In various embodiments, referring now to FIGS. **241-243**, an anvil **7240** can comprise a frame **7244** and a plurality of pocket plates **7243** which can be inserted into the frame **7244**. Similar to the above, each pocket plate **7243** can comprise a plurality of forming pockets **7242** defined therein. In at least one embodiment, the anvil frame **7244** can comprise retention slots **7246** defined therein which can each be configured to receive a retention rail **7247** extending from a pocket plate **7243**. In order to assemble the pocket plates **7243** to the anvil frame **7244**, the side walls **7245** of the anvil frame **7244** can be flexed or splayed outwardly, as illustrated in FIG. **242**, in order to widen the retention slots **7246** such that each reten-

122

tion slot **7246** can receive a retention rail **7247** of a pocket plate **7243** therein. Once the retention rails **7247** have been positioned in the retention slots **7246**, the side walls **7245** can be released, as illustrated in FIG. **243**, thereby allowing the frame **7244** to resiliently contract and/or return to its unflexed state. In such circumstances, the retention slots **7246** can contract and thereby capture the retention rails **7247** therein. In certain embodiments, the retention rails **7247** and/or the retention slots **7246** can comprise one or more co-operating tapered surfaces which, after the flexed retention slots **7246** have been released, can form a taper-lock engagement which can retain the retention rails **7247** in the retention slots **7246**. Similar to the above, the pocket plates **7243** can be comprised of the same material as or a different material than the frame **7244**. In at least one such embodiment, the plates **7243** can be comprised of a ceramic material, for example, and the frame **7244** can be comprised of a stainless steel and/or titanium, for example. In various circumstances, depending on the materials used, at least one brazing process and/or at least one welding process, for example, could be used to secure the plates **7243** in the frame **7244**.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Preferably, the invention described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

While this invention has been described as having exemplary designs, the present invention may be further modified within the spirit and scope of the disclosure. This application

123

is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

What is claimed is:

1. A surgical instrument comprising:

a handle assembly;

a flexible spine assembly operably coupled to said handle assembly and protruding therefrom;

an elongated shaft assembly received on said flexible spine assembly and having a reconfigurable shaft segment that is selectively reconfigurable between a linear configuration wherein all portions of said reconfigurable shaft segment are substantially coaxially aligned with each other and configurations wherein at least one said portion of said reconfigurable shaft segment is orientated in a non-linear orientation relative to at least one other said portion of said reconfigurable shaft segment, said elongated shaft assembly further having a closure tube segment that is axially movable relative to said reconfigurable shaft segment in response to firing motions applied thereto from a firing system operably supported in said handle assembly;

a locking system for selectively locking tubular links in a desired orientation relative to each other, said locking system comprising:

at least one selectively expandable locking bladder extending through said reconfigurable shaft segment of said elongated shaft assembly and being selectively expandable with a fluid material pumped therein by a fluid pumping system operably supported by said handle assembly, such that when each said selectively expandable locking bladder is in an expanded condition, said tubular links are substantially immovable relative to each other.

2. A surgical instrument comprising:

a handle assembly;

a flexible spine assembly operably coupled to said handle assembly and protruding therefrom;

an elongated shaft assembly received on said flexible spine assembly and including a reconfigurable shaft segment defining a shaft axis and comprising a plurality of movably interconnected tubular links that cooperate to form a hollow passage therethrough to operably support said flexible spine assembly therein, each said tubular link configured to rotatably move relative to each adjacent said tubular link in any radial direction about said shaft axis to enable said reconfigurable shaft segment to be selectively reconfigurable between a linear configuration wherein all portions of said reconfigurable shaft segment are substantially coaxially aligned with each other and configurations wherein at least one said portion of said reconfigurable shaft segment is orientated in a non-linear orientation relative to at least one other said portion of said reconfigurable shaft segment, said elongated shaft assembly further having a closure tube segment that is axially movable relative to said reconfigurable shaft segment in response to firing motions applied thereto from a firing system operably supported in said handle assembly;

a locking means on each said tubular link for selectively preventing any relative movement between said adjacent said tubular links when said adjacent said tubular links are in a locked configuration; and

an end effector coupled to said flexible spine assembly and having first and second jaw members movable relative to

124

each other from an open position to closed positions in response to axial movement of said closure tube segment.

3. The surgical instrument of claim 1 wherein each said movably interconnected tubular link comprises a tubular body portion that has a ball-like coupler formed on one end thereof, said ball-like coupler having a passage therethrough that extends into a hollow socket formed on another end thereof that is sized to rotatably receive said ball-like coupler of another said tubular link therein.

4. The surgical instrument of claim 1 wherein each said tubular link has at least one latch portion formed on a distal end portion thereof and a locking portion formed on a proximal end portion thereof corresponding to each said latch portion on an adjacent said tubular link wherein each said latch portion on one said tubular link is configured for releasable retaining engagement with a said corresponding locking portion of said adjacent said tubular link coupled thereto.

5. The surgical instrument of claim 4 wherein each said latch portion comprises a flexible latch member and wherein each said locking portion comprises a coupler member having a latch-receiving notch therein.

6. A surgical instrument comprising:

a handle assembly;

a flexible spine assembly operably coupled to said handle assembly and protruding therefrom;

an elongated shaft assembly received on said flexible spine assembly and operably coupled to said handle assembly, said elongated shaft assembly comprising:

a reconfigurable shaft segment comprising:

a plurality of movably interconnected tubular links, each said tubular link having a tubular body portion having a spherically-shaped coupler formed on one end thereof and having a passage therethrough that extends into a hollow spherical socket formed on another end thereof that is sized to rotatably receive said spherically-shaped coupler of another said tubular link therein; and

a locking means on each said tubular link for locking adjacent said tubular links in a desired orientation relative to each other to prevent any relative motion therebetween and wherein said elongated shaft assembly further comprises a closure tube segment movably supported on a corresponding portion of said spine assembly for selective axial travel thereon in a distal direction away from said handle assembly and in a proximal direction towards said handle assembly and wherein said surgical instrument further comprises:

a firing system operably supported by said handle assembly and interfacing with said closure tube segment to selectively cause said closure tube segment to axially move in said distal and proximal directions on said corresponding portion of said spine assembly; and

an end effector coupled to said spine assembly and having first and second jaw members movable relative to each other from an open position to closed positions, said first jaw member configured to support a staple cartridge therein, said first and second jaw members configured to be moved between said open and closed positions in response to axial movement of said closure tube segment on said spine assembly.

7. The surgical instrument of claim 6 wherein said locking means comprises:

a latch portion formed on a distal end portion of each said tubular link; and

125

a lock portion formed on a proximal end portion of each said tubular link and configured for releasable engagement with a corresponding said latch portion on an adjacent said tubular link.

8. The surgical instrument of claim 7 wherein each said latch portion comprises a flexible latch and wherein each said lock portion comprises a latch-receiving notch portion.

9. A surgical instrument comprising:

a handle assembly;

a flexible spine assembly operably coupled to said handle assembly and protruding therefrom;

an elongated shaft assembly received on said flexible spine assembly and operably coupled to said handle assembly, said elongated shaft assembly comprising:

a reconfigurable shaft segment comprising:

a plurality of movably interconnected tubular links, each said tubular link having a tubular body portion having a spherically-shaped portion formed on one end thereof and having a passage therethrough that extends into a hollow spherical socket formed on another end thereof that is sized to rotatably receive said spherically-shaped portion of another said tubular link therein; and

at least one selectively expandable locking bladder extending through said plurality of movably interconnected tubular links and being coupled to a fluid pumping assembly operably supported in said handle assembly such that when each said locking bladder is in an expanded condition, said tubular links are immovable relative to each other and wherein said elongated shaft assembly further comprises a closure tube segment movably supported on a portion of said spine assembly for selective axial travel thereon in a distal direction away from said handle assembly and in a proximal direction towards said handle assembly and wherein said surgical instrument further comprises:

a firing system operably supported by said handle assembly and interfacing with said closure tube segment to

126

selectively cause said closure tube segment to move on said corresponding portion of said flexible spine assembly; and

an end effector coupled to said spine assembly and having first and second jaw members movable relative to each other from an open position to closed positions, said first and second jaw members configured to be moved between said open and closed positions in response to axial movement of said closure tube segment.

10. The surgical instrument of claim 9 wherein said fluid pumping assembly comprises a pumping member for pumping air under pressure into each said expandable locking bladder and configured to selectively vent said pressurized air therefrom.

11. The surgical instrument of claim 9 further comprising: a knife member having a tissue cutting edge formed on a distal end thereof, said knife member movably supported within said distal closure tube segment; and

a flexible knife advancement member movably supported within said reconfigurable portion of said closure tube assembly and interfacing with a tissue cutting control system operably supported by said handle assembly for selectively applying a knife advancement motion to said knife member such that the distal end thereof is moved axially within said end effector.

12. The surgical instrument of claim 9 wherein said first jaw member is configured to support a staple cartridge therein.

13. The surgical instrument of claim 9 wherein at least one said selectively expandable locking bladder comprises:

a first selectively expandable locking bladder extending through each said movably interconnected tubular links in a first location; and

a second selectively expandable locking bladder extending through each said movably interconnected tubular links in a second location that differs from said first location.

14. The surgical instrument of claim 13 wherein said second location is diametrically opposite from said first location.

* * * * *